xT Nova NanoLab
User's Manual

4022 262 52351/02

01/07/2007

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This manual was produced using FrameMaker™ document publishing software

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PREFACE

About this Manual

This *User Manual* for your Nova NanoLab is divided into the following chapters:

- **1. SAFETY & HANDLING** provides important information required during operation and maintenance for product safety and personal safety.
- **2. SYSTEM OVERVIEW** gives the basics about your system's capabilities.
- **3. SYSTEM OPERATION** gives procedures for several system on/off modes, including Startup, Overnight Mode, and Emergency Shutdown.
- **4. USER INTERFACE** describes the interface that controls system operation, giving the function of each Tool, Menu item and Control Page.
- **5. WORKING WITH NOVA NANOLAB** gives procedures of how to use the system.
- **6. STAGES** gives a full description of movement for each stage and the software control.
- **7. MAINTENANCE** step by step cleaning procedures.
- **8. HARD & SOFTWARE OPTIONS** that are relevant options integrated in or accessory to the Nova system.
- **9. ALIGNMENTS** for the Electron and Ion columns that can be performed by the Supervisor.

How to Use this Manual

At the beginning is a main Contents, List of Figures and a List of Tables covering the whole Manual. Each chapter has a Contents of the subjects specific to that chapter. Included in some chapters are easy-to-follow tables outlining task-oriented procedures. High-lighted text can also be found in descriptive paragraphs to aid association of items to graphics. On-line documentation is also available with the software and can be activated from the Help menu or by clicking F1.

More explicit information on Safety issues can be found in Chapter 1.

Conventions for Controls

References to specific knobs, buttons, labelled functions on the system and in software are labelled in small capitals or highlighted text. A sentence such as: “Click on the MEASUREMENT button to start this function” refers to the software button itself.

Finding What You Need

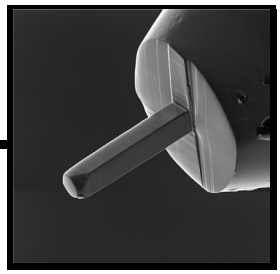
This manual has been organized so you can find information in several ways. You can read the manual from beginning to end (highly recommended but rarely done). Be sure to read the safety section, before operation, in Chapter 1.

Once your system is up and running, you can search for information in the main contents or the individual contents proceeding each chapter.

Major headings have been hung in the left column to help you scan for the basics within a chapter. That column provides space for your own notes as well.

Tables and Figures are numbered within each chapter and are listed after the main Contents by chapter for the whole manual.

1 SAFETY & HANDLING



Site Requirements

Verify that the safety and environmental requirements of the workstation site, which are the responsibility of the customer, are satisfied. In particular, the pump exhaust requirements, the electrical supply and grounding (earthing) requirements, floor loading, and any local codes regarding earthquake safety are important safety issues.

Electron Column Precautions

The Whole system conforms to:

- EN61010-1 for Safety requirements for electrical equipment for measurement, control and laboratory use.
- X-ray emission below 1 μSv/h at 10 cm distance from the surface.

Trained Service Personnel

Before starting any service task on an FEI Company product, such as an electron microscope or ion beam equipment, or any related accessories or third party equipment, the service engineer concerned must first have read and understood the relevant sections of the FEI Service Safety Manual.

The FEI Service Safety Manual, order code number 4022 190 50058, contains explicit instructions on safe working methods, descriptions of the various warning symbols and labels used on FEI equipment, and Material Safety Data Sheets for all toxic gases and materials which may be present.

A hardcopy of the FEI Service Safety Manual is shipped with every FEI Company electron microscope or ion beam instrument, and it is also present in electronic form on the FEI Customer Service CD-ROM.

WARNING! ONLY QUALIFIED FEI SERVICE ENGINEERS SHOULD ATTEMPT TO PERFORM SERVICE MAINTENANCE OR REPAIRS. OPENING ACCESS DOORS, REMOVING SERVICE PANELS, AND OTHER MAINTENANCE ACTIVITY CAN EXPOSE YOU TO ELECTRICAL, CHEMICAL OR MECHANICAL HAZARDS, COMPRESSED AIR, OR X-RAYS.

User Maintenance

CAUTION! Never attempt maintenance or service of any kind on the electron column, other than that described for the Supervisor, in this User Manual.

Allow only trained personnel to perform maintenance procedures.

Always observe appropriate safety practices in dealing with electronic circuitry. Read and understand the safety precautions in this chapter and throughout the manual. Observe industry-approved safety methods and procedures.

If you have any doubt regarding approved safety procedures, contact safety personnel at your company, or representatives of your state, territory or province, or federal government.

Terms and Symbols

Symbols and messages

The following messages are used throughout FEI xT Nova manuals to highlight information.

NOTE: Text of the note.....

A note emphasizes information requiring special attention.

CAUTION! Text of the caution....

A Caution message appears where special handling is required to prevent product damage.

WARNING! TEXT OF THE WARNING...

A Warning message appears where special handling is required to prevent personal injury or death.

DANGER! Text of the danger message....

A Danger message identifies an immediate personal risk of injury or death and gives appropriate precautions.

The following signs may be visible on the instrumentation, avoid contact with these points.

DANGER! High Voltage

Protective ground (earth) terminal

Voltages

According to the American National Standards Institute (ANSI) guidelines, a shock hazard exists when voltage levels are present which are 30 V rms or 42.4 V peak. Use extreme caution whenever a shock hazard is present. As a good safety precaution, always expect a hazardous voltage in an unknown circuit before measuring.

WARNING! COMPONENTS MAY HAVE POTENTIALLY HIGH VOLTAGES (UP TO 30kV).

Operators and service personnel must be trained on potential safety hazards and safe techniques, and must observe all warnings and cautions encountered on the system and in the manuals. No person should perform any operations without prior training.

Interlocks

Components include safety interlocks to minimize high voltage hazards. Safety interlock circuitry is provided to protect system users. Overriding interlocks is dangerous and should never be done by untrained personnel.

After completing procedures for which an interlock was disconnected, always reset (or reconnect) and test the interlock before proceeding. Cover interlocks reset automatically when the covers are replaced.

Line Voltage

Line voltage (120 to 240 V AC) may be present in various locations within the system, even when the system or instrument is turned off. Completely disconnect the unit from line voltage by disconnecting the AC plug from the AC power source before performing service or maintenance.

WARNING! SERVICE AND TROUBLESHOOTING IN THESE AREAS IS PERFORMED ONLY BY TRAINED FEI SERVICE ENGINEERS.

Cords/Cables

Never connect or disconnect any cables or connections while power is applied to the system or components. Doing so is potentially hazardous to service personnel and could cause damage to the system or its components.

DC Cable Colour-Coding System

Internal DC power wiring in the main console is colour-coded according to Table 1-1.

TABLE 1-1 DC POWER WIRE CODING

Color	Voltage
Blue	0
Yellow	+5
Gray	+15
Lavender	-15

AC Cords

Plug the unit AC cords only into an approved power source. Use only power cords that are in good condition. If replaced, use AC cords rated to at least the rating of the original AC cord.

Each power cable is labelled with a destination and origin and are colour-coded according to Table 1-2.

TABLE 1-2 AC CABLE CODING

North American Color	International Color	Meaning
Solid Green	Green with Yellow Stripe	Ground
Black	Brown	Line
White	Blue	Neutral

Miscellaneous Cables

Check cables periodically for possible wear, cracks, or breaks. If any defects are found, contact service personnel.

Main Power

The system main power should only be plugged into the approved power receptacle, as identified by system documentation.

Ground (Earth)

Some components must be grounded to operate safely. Do not defeat grounding or use an ungrounded power source. In the event of loss of a protective ground connection, all accessible conductive parts (including knobs and controls that may appear as insulating) can render an electric shock.

Cover/Panels

Do not operate or plug in any electrical unit without the protective covers or panels installed. Only qualified persons aware of the electrical hazards should perform maintenance or service operations.

Fuses

Only trained service personnel should replace fuses. Replace fuses only with fuses of the same type, voltage rating, and current rating.

Emergency Button

Emergency Off (EMO) Switches

In an emergency, press one of the large yellow and red EMO switches to turn off all hazardous system voltages. The dry pump shuts down and the specimen chamber vents, but the electron and ion columns remain under vacuum.

! CAUTION! A FEI Service Engineer or a Authorized Supervisor must restart the system after an emergency power off.

The EMO switches are latching. Once pushed in, they must be rotated in the direction of the arrows to reset

FIGURE 1-1 EMO BUTTON

EMO switches are located on the back of the E2 Console

FIGURE 2 EMO BUTTON LOCATION

Chemicals

Before using any chemicals, obtain and read a Material Safety Data Sheet relating to the substance. Be aware of hazards and how to avoid them, before using or handling any chemical.

Solvents

Use solvents carefully and in sparing quantities. Before using any solvent, read the Material Safety Data Sheet. Avoid hazards listed on the Material Safety literature, and avoid spillage, skin contact, eye contact, and vapour inhalation.

WARNING! VOLATILE AND CORROSIVE SUBSTANCES CAN DIFFUSE THROUGH CONTACT LENSES DESPITE REASONABLY WELL VENTILATED CONDITIONS.

Moreover, contact lenses are difficult to remove when an irritant chemical enters the eye, making irrigation ineffective. Care must be taken to address the issue of contact lens worn by those coming into contact with such solvent fumes.

Nitrogen

Nitrogen may be used to vent the system. Nitrogen is not poisonous, but is a potential asphyxiant.

WARNING! SUFFOCATION IS POSSIBLE IF NITROGEN OR LIQUID NITROGEN IS RELEASED IN AN ENCLOSED ROOM WITHOUT ADEQUATE VENTILATION.

Liquid Nitrogen

Liquid nitrogen, used in the EDX system, has the potential to cause frostbite if direct contact with skin occurs.

On standing, liquid nitrogen picks up oxygen from the air and forms liquid oxygen in solution. Treat any liquid nitrogen that is not fresh as though it had all the hazards of liquid oxygen.

Miscellaneous Precautions

Electric Fans

Some instruments in the system may be air-cooled. Do not block the air flow to or from the fans. Do not operate fans with the protective covers or filters removed. Keep fingers, loose clothing, etc. away from fans. Periodic filter maintenance may be required to prevent overheating.

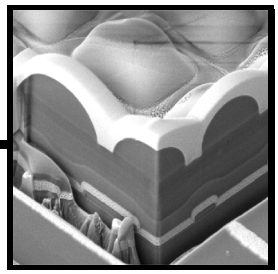
Pump Exhaust

Failure to provide proper exhaust filtering may discharge oil mist into the environment. Such oil mist may be an environmental hazard as well as a health hazard in an enclosed room.

Corrosion

Components are painted, plated, or otherwise treated to resist corrosion. However, the components must be handled and stored properly to prevent corrosion. Observe precautions carefully.

2 SYSTEM OVERVIEW



The Nova NanoLab integrates ion and electron beams for FIB and SEM functionality in one machine. Users can switch between the two beams for quick and accurate navigation and milling. Convergence of the SEM and FIB at short working distance allows precision “slice-and-view” cross-sectioning and analysis at high resolution.

The FIB is a Magnum™ ion column or Sidewinder™ ion column that provides fast, precise milling and high-resolution images of the sample surface.

The SEM column takes advantage of FEI’s most advanced Hexalens™ design for ultimate image resolution at low beam energies. It offers non destructive imaging capability at a working distance optimized for ultra-high resolution and can produce images magnified over 500 kx in mode 1 and greater than 2500 kx in mode 2. Topographic data allows for monitoring of metal step coverage and etch processes.

The xT Nova NanoLab 600 chamber, stage and wafer holder accommodates wafers up to 6", or other devices, in a high-vacuum environment. The high accuracy, five-axis stage provides computer control and automation of all axes. The NanoLab 200 has a high accuracy, five-axis stage, for smaller sample types, but also with manual controls.

FEI’s Gas Injection Systems (GIS) use Enhanced Etch™ for fast material removal with minimal redeposition, as well as metal deposition and insulator deposition materials.

The xT Nova NanoLab was designed for:

- Data storage
- Process yield engineering
- Etching
- Lithography
- Metal and other materials deposition
- Fabrication of micro- and nanostructures

FIGURE 2-1 xT NOVA NANOLAB 200 SYSTEM

FIB/SEM Capabilities

FIB/SEM workstations provide an expanded range of capabilities not possible with separate FIB and SEM tools:

- Electron beam high-resolution images of FIB cross sections without eroding the feature of interest
- Real-time cross-section images with the electron beam during FIB milling
- Focused electron beam charge neutralization during FIB milling
- Focused ion beam charge neutralization during SEM imaging
- High resolution elemental microanalysis of defect cross sections
- Image sample surface with the electron beam during navigation without erosion or gallium implantation from the ion beam
- TEM sample preparation with *in situ* conductive coating

Control of the Beams

FIB/SEM workstations ideally position the point of interest for simultaneous ion beam cross-sectioning and electron beam viewing. Separate scan generators for the two beams permit coupled or independent scan patterns and magnifications. Imaging while milling aids in defining milled features.

Immediate electron beam images of cross sections are possible without stage motion or sample transfer. Immediate high-resolution SEM imaging after FIB milling also prevents exposure of milled cross sections to atmospheric contaminants.

Gas Deposition

Multiple gas injectors can be installed for material deposition in conjunction with either electron or ion beam pattern definition. Electron beam-induced deposition offers the advantage of not sputtering the deposited material or implanting gallium simultaneously.

Gas Enhanced Etch

The Gas Injection System (GIS) also provides enhanced etching capability for high aspect ratio drilling with minimal redeposition, preferential etching of cross-section surfaces prior to SEM imaging, and rapid milling of TEM sections.

Up to five GIS beam chemistries can be installed on the workstation, depending on system configuration. This self-contained apparatus allows the precursor material to be contained entirely within the vacuum system for simple, flexible, and safe operation.

X-Ray Analysis Capability

Energy Dispersive X-ray (EDX) provides elemental analysis capability for identification of surface and subsurface features. Convergence of the SEM, FIB, and EDX at short working distance allows precision “slice-and-view” cross-sectioning and chemical analysis at high resolution. Various vendor options are compatible with the workstation.

User Interface

The xT software interface integrates SEM and FIB functionality within a Windows 2000™ or Windows XP™ operating environment.

The user interface consists of a single high-level user shell employing applications programs with vector parameter files defining specific instrument settings for particular applications ensuring reproducibility of complex procedures.

An intermediate software layer, acting on instructions from the application layer controls the column, detector(s), stage, EDX and vacuum functions. This layer also provides management of image capture, storage, and data output devices.

A Manual User Interface (MUI) offers additional flexibility for controlling magnification, beam shift, focus, contrast and brightness, and stigmation.

Computerized Stage

A computer-controlled, 5-axis stage offers fast, repeatable, and precise sample manipulation. Two versions are available:

- 200 (50 x 50 mm)
- 600 (150 x 150 mm)

Optical Camera

A low-magnification optical image obtained with the Optical Camera assists in overall spatial orientation on highly repetitive or extremely irregular samples. It also aids in positioning gas injectors on packaged IC parts or other non uniform samples.

Supervisor and User Log-on

The SUPERVISOR and all USER level accounts run under the same Windows 2000 account, and are the only types of account available to the customer under normal circumstances.

Refer to Chapter 3 for Start-up and Log-on/Log-off

NanoLab Options

A range of hardware and software are available as options for xT Nova NanoLab workstations. This range will be extended when new items become available.

Some of the options are:

- Gas injectors
- Detectors:

  CDEM

  STEM 1
- FIB Software Options:

  AutoFIB

  Auto Slice & View

  AutoTEM
- Sample holders:

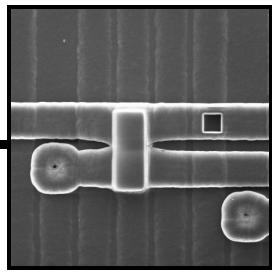
  UMB (Universal Mounting Base) sample holder set

  Vise Holder

  Wafer Holders
- EDX Software Options
- Image Analysis
- 3D Reconstruction Software

Contact your FEI sales representative for more up-to-date information on system options.

3 SYSTEM OPERATION



Nova NanoLab

Overview

FEI systems are started at the time of installation to obtain an adequate high vacuum for the system and remain on unless there is a power failure or some catastrophic event.

This chapter describes:

- System Status
- Log On/Log Off
- Leaving the system overnight
- Returning to operation
- Standby Mode
- Startup after Standby
- Complete System Shutdown
- Startup from Complete System Shutdown
- Emergency power off (EMO)

NOTE:
Before starting the workstation, check for the presence of:

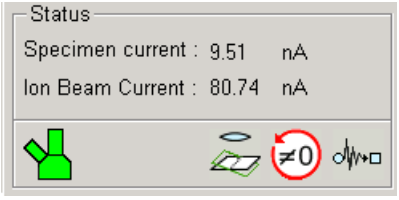
- Electrical power
- Compressed air
- Cooling water
- Nitrogen for venting

With the exception of nitrogen, interlocks prevent the vacuum system from operating if the others are not present.

System Status

Hardware System

There are three main vacuum sections: E-Source/Column, I-source/ Column and the Specimen Chamber. In High Vacuum mode, all sections are under high vacuum. All valve operations are fully automatic.



Vacuum Status

In the Status module at the bottom of any page the actual vacuum status is displayed with the coloured icon. This icon represents three vacuum sections schematically, each of which may have three possible colours with the following meaning:

- **Green**: pumped to the desired vacuum mode (HiVac)
- **Orange**: transition between two vacuum statuses (pumping or venting)
- **Grey**: vented

Log-On / Log-Off

Supervisor and User Log-On/Log-Off

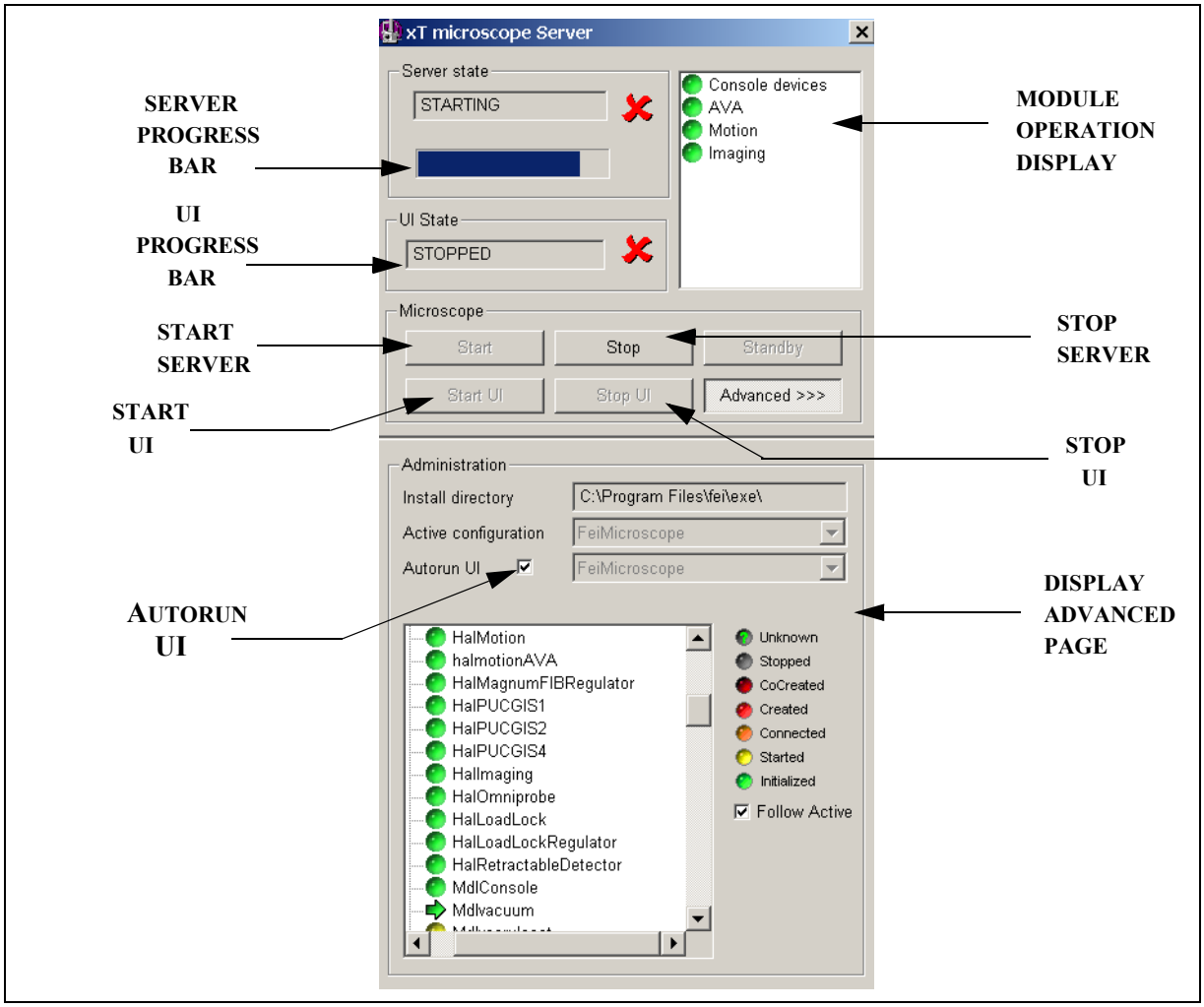
First log-on under Windows 2000 as SUPERVISOR or USER, allow the server and UI to load, then start the UI with a password. A default password is allocated on installation to the Supervisor for the Windows and UI Log-on.

When the status of the UI is 'waiting' for a new USER only the Server state is active and the UI state non-active. Therefore changing the USER does not require Log-Off / log-On at Windows 2000 level but just Log-Off / Log-On at the UI level.

Launch Server level

When starting the Nova NanoLab operating program a progressive dialog for Server and UI is displayed. The Server needs to be launched first followed by the UI. Press the Start server button.

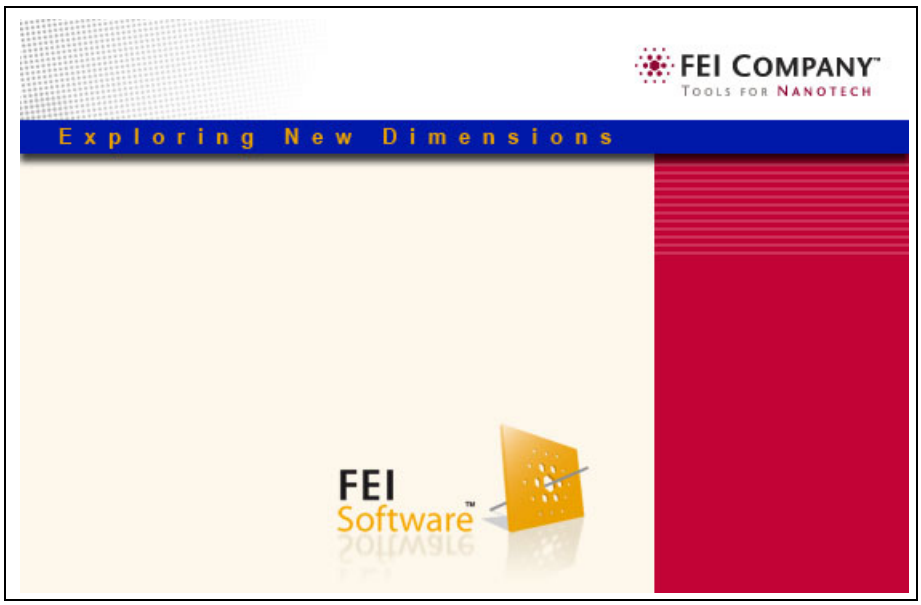
FIGURE 3-1 START-UP DIALOG



Launch UI Level

When the Server is fully launched the Start UI button becomes active. Click on the Start UI button and a Splash-screen appears during the UI loading. This is then replaced by the UI.

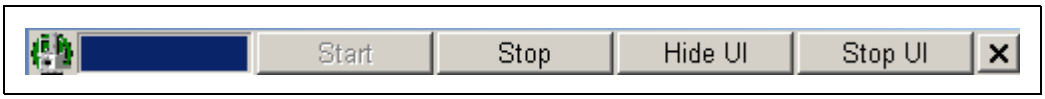
FIGURE 3-2 SPLASH SCREEN FOR NOVA NANOLAB



Minimized Server dialog

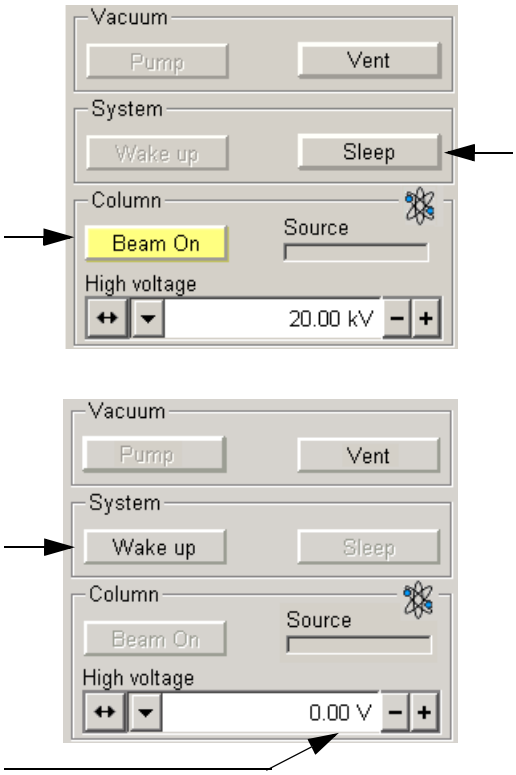
The start-up dialog can be minimized once the UI is established by clicking with the right mouse button in the top bar of the dialog. this opens a further dialog that offers the chance to minimize the server to the top bar of the UI.

FIGURE 3-3 MINIMIZED SERVER DIALOG



NOTE: The stage will need to be homed before full operation of the UI is possible. A dialog will display in the screen center for this purpose after the Log-on dialog has closed. If it is not homed at the first displayed dialog it can be homed by selecting Home Stage from the Stage Menu later.

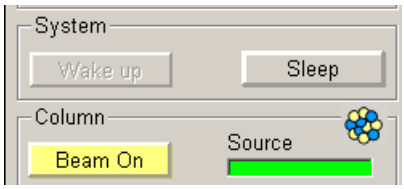
Leaving the System Overnight



Overnight and weekends

If you don't plan to use the workstation until the following day or weekend, use the SLEEP button facility on the **Beam Control** page. This switches off the ion column source, but leaves the electron column filament current on. Returning to full operation takes only a few minutes.

TABLE 3-1 LEAVING THE SYSTEM OVERNIGHT

Step	Action
1	Click on the SLEEP button in the SYSTEM module to switch off both beam simultaneously. The Ion column source switches off completely. This is seen by reduction in the SOURCE progress bar in the column module when the Ion beam is selected.  The Electron column reduces to filament current on only.
2	The **Beam Control** page will then indicate that the system is ready to wake up via the WAKE UP button in the SYSTEM module.
3	Click on STOP UI in the **Server bar**. This action will also act as Log-off current user. Switch off the monitor.

Returning to operation

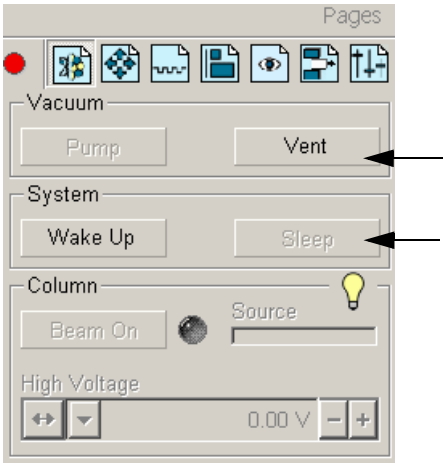
Operation

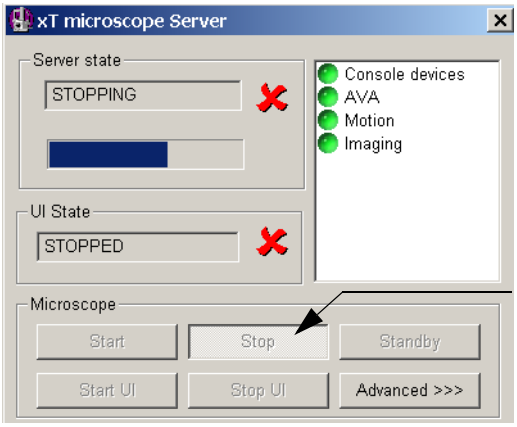
This procedure is almost the previous in reverse.

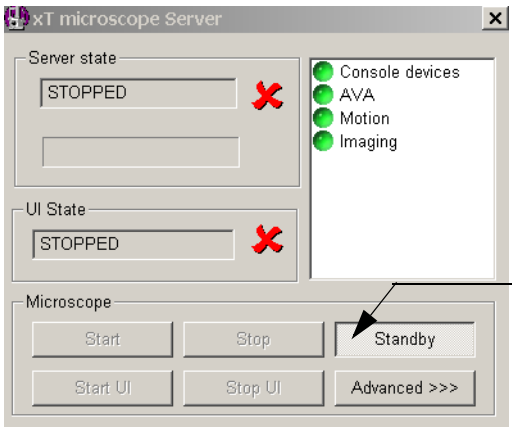
TABLE 3-2 RETURNING TO OPERATION

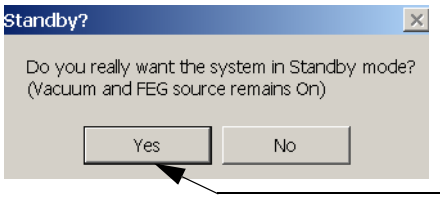
Step	Action
1	Switch on the monitor. Click on the START UI button on the **Server bar**. The UI splash dialog appears on the screen followed by the UI.
2	Log-on the UI
3	Click on the WAKE UP button in the SYSTEM module to switch on the Ion column sources completely. This is seen by an increase in the SOURCE progress bar in the column module when the Ion beam is selected.
4	The **Beam Control** page will then indicate that the system is ready and only the SLEEP button in the SYSTEM module is active.

Standby Mode









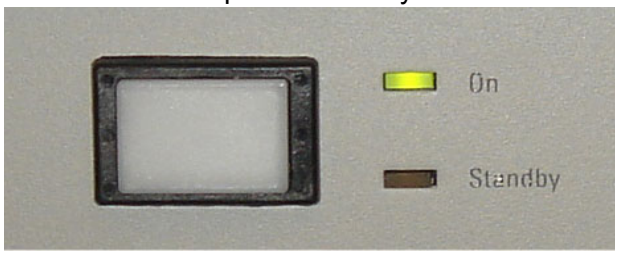
Going into Standby Mode

Standby Mode is a system shutdown process used when the system will not be used for several weeks or during service.

Standby mode is different from the system being completely turned off and is used mostly by service personnel. In the standby mode, the electronics racks are powerless except for the E-column source, E-column, I column (IGP's) vacuum pump and computer. All IGP's are still running but The TMP (Turbomolecular Pump) and roughing pump shut down. The chamber is not vented by Nitrogen gas.

The system can be left in this state if utilities (water, air, nitrogen), other than electrical, need to be disconnected.

TABLE 3-3 GOING INTO STANDBY MODE

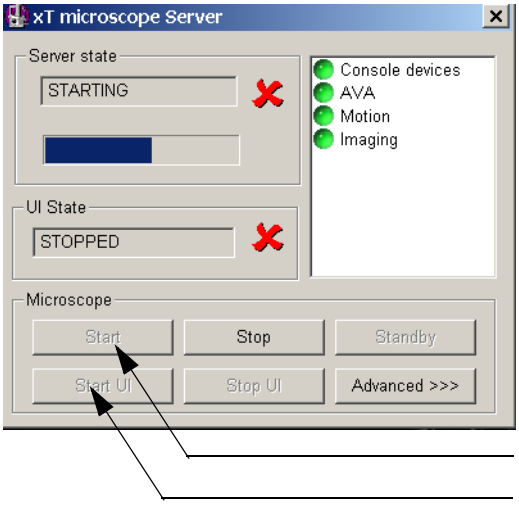
Step	Action
1	In the **Beam Control** page, click the **Sleep** button to switch off both beams. The Ebeam FEG source is still running but the ion source and both HT's will be turned off.
2	Select **tilt 0 (Ctrl+E)** from the **Stage** menu..
3	Remove your sample if needed by the Load Lock.
4	Click **Stop UI** to stop the xT Microscope User Interface. Double Click the Blue progress bar.
5	Click **Stop** to stop the server, , Wait until the xT microscope server stops, then click the **Standby** button on the front panel of the system.. 
6	Select **YES** in the dialog box, the system will go to the **Standby** mode.

When Standby mode is selected, in order to recover from a failure, it is better at that moment to restart the Microscope PC before restarting the microscope.

Startup After Standby

Startup

It is assumed here that all external supplies are present. The startup procedure is fully automatic.



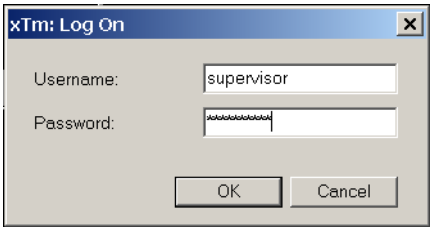


TABLE 3-4 STARTUP AFTER STANDBY

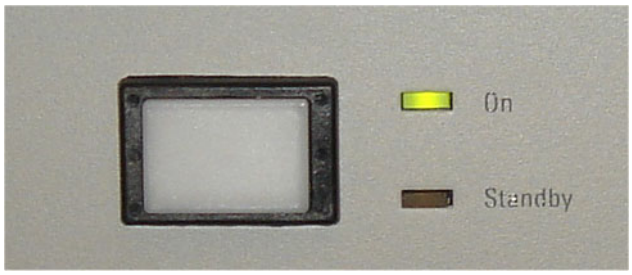
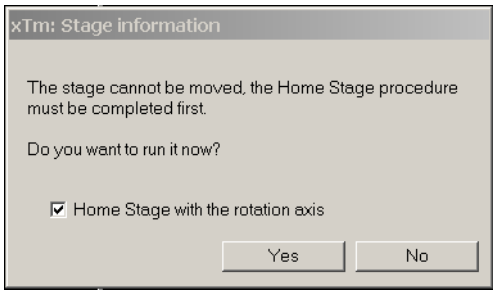
Step	Action
1	Press the **Power ON/Standby** button on the front control panel of the microscope.  Open the microscope cabinet and press microscope computer power ON/OFF button to switch ON.
2	Start the software by clicking on the **FeiSystemControl** icon to display the xT Microscope Server dialog.. Click on the **Start** button. Click on the Advanced button. Wait until the dialogue is fully functional (All LEDs needs to be green).
3	Select **Start UI**. Once the microscope server has started the Splash screen appears followed by the xT User Interface dialog. Log-on is requested. Input a user name and password to activate the Microscope User Interface. Once logged-on leave the stage home dialogue box unselected.
4	Click **Pump** in the **Beam control** page to pump the Specimen chamber.

TABLE 3-4 STARTUP AFTER STANDBY

Step	Action
5	Once the vacuum is ready, click **Wake Up** to start the ion source if needed.
6	Select **Yes** in the Home Stage dialogue to home the stage. 
7	If a CDEM is installed in the system, go to the **Alignment** page and select adjustment **29-Auto Zero detectors** to autocalibrate the CDEM.
8	The system is now ready to use.

NOTE: Wake Up not only starts the Ion source and HT but also switches on the Electron Beam HT. if this is not immediately required then it can be switched off in the E-Beam page.

Complete System Shutdown

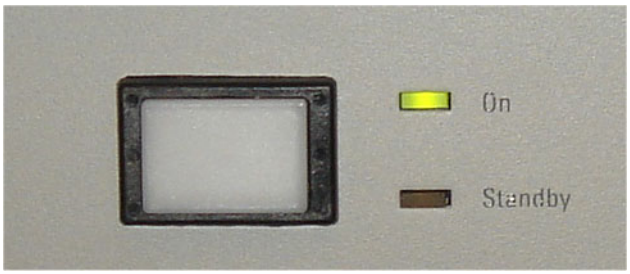
Shutdown

Complete shutdown should be performed only if absolutely necessary and for the shortest possible time, so as to recover the column vacuum without the necessity of a system pump. Normally, one would only perform a complete shutdown for transportation of the system or for service actions, like repair to essential electrical and air supplies. The shutdown procedure brings the system to a non-powered state, where the vacuum in the Electron and Ion column area is no longer supported by running pumps and IGPs. All valves are closed and the specimen chamber is vented. This procedure should only be carried out by a Supervisor.

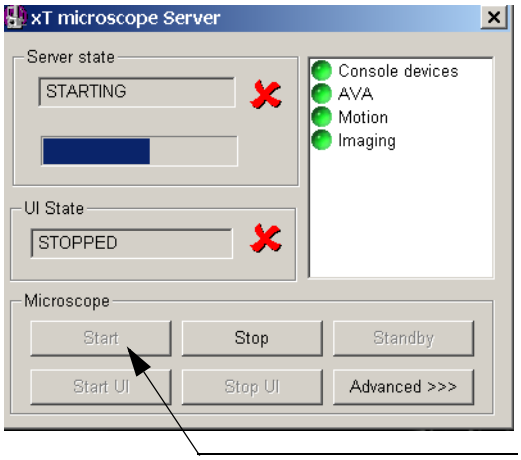
NOTE: Do not use this mode unless you are positive that you want to turn off the E-Beam source.

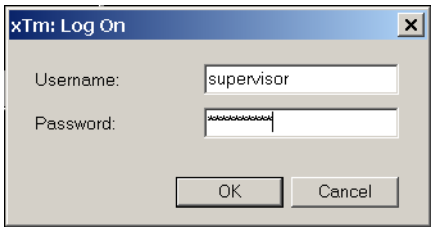
The emission characteristics of the source are dependent on the shape of the tip. When the source is turned off, it cools. Reheating the source during startup changes the shape and emission characteristics dramatically, requiring the column to be aligned. It also reduces the lifetime of the source.

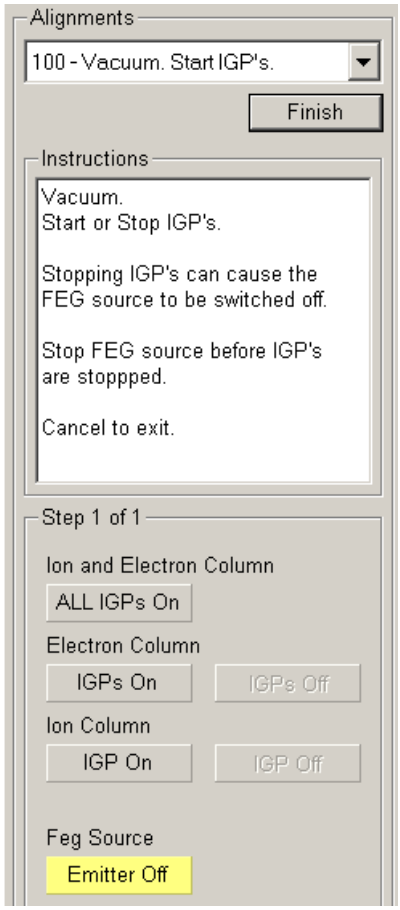
TABLE 3-5 COMPLETE SHUTDOWN PROCEDURE

Step	Action
1	Set the system to **Standby** mode as described above, then press and hold the front panel On/ Standby button for 5 second, then release the button. The system will now be shut down completely. 
2	Shut down the microscope computer by Windows software.

Startup from complete System Shutdown







Startup

The Startup procedure has to be followed when ever the system has been shutdown for service or due to a power failure. After startup has been initiated observe the system for the first 30 minutes to confirm that the IGPs show sufficient vacuum to continue and complete the procedure.

TABLE 3-6 STARTUP FOR OPERATION

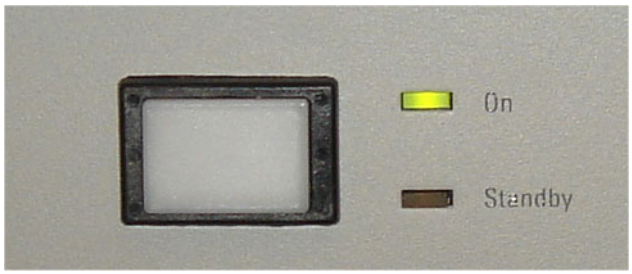
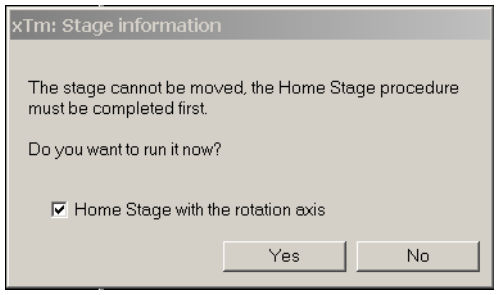
Step	Action
1	Press the **Power ON/Standby** button on the front control panel of the microscope.  Open the microscope cabinet and press the microscope computer power ON/OFF button to ON.
2	Start the software by clicking on the **FeiSystemControl** icon to display the xT Microscope Server dialog.. Click on the **Start** button. Click on the Advanced button. Wait until the dialogue is fully functional (All LEDSs needs to be green).
3	Select **Start UI**. Once the microscope server has started the Splash screen appears followed by the xT User Interface dialog. Log-on is requested. Input a user name and password to activate the Microscope User Interface. Once logged-on leave the stage home dialogue box unselected.
4	Once you logon to the user interface, you will find that both the **E Column IGP** and **I column IGP** are turned off and the pressures are unknown. To turn on the IGPs, Go to the **Alignment** page, select **100-Vacuum Start IGP's,** then follow the instructions.

TABLE 3-6 STARTUP FOR OPERATION

Step	Action
5	First press the **IGPs on** button under **Electron Column**, wait for the Electron column IGP to start, then press **IGPs On** under **Ion Column** to start the ion column IGP. Once both the columns have vacuum readings, click **Finish** to exit **100-Vacuum Start IGP's**.
6	Click **Pump** in the **Beam control** page to pump the Specimen chamber.
7	Once the vacuum is ready, click **Wake Up** to start the ion source if needed.
8	Select **Yes** in the Home Stage dialogue to home the stage.  xTm: Stage information The stage cannot be moved, the Home Stage procedure must be completed first. Do you want to run it now? Home Stage with the rotation axis Yes No
9	If a CDEM is installed in the system, go to the **Alignment** page and select adjustment **29-Auto Zero detectors** to autocalibricate the CDEM.

NOTE: When vacuum pressures are too high at point 5 in the procedure for system operation then a bakeout is required. If this is the case a trained FEI Service Engineer or a FEI trained Supervisor must restart the system.

Emergency Power Off (EMO)

In an emergency, press one of the large yellow and red EMO switches to turn off all system hazardous voltages. The system will be brought into a safe state, and turn of completely.

The EMO switches are latching. Once pushed in, they must be rotated in the direction of the arrows to reset.

FIGURE 3-4 EMO BUTTON

EMO switches are located on the back of the E2 Console.

FIGURE 5 EMO BUTTON ON BACK OF THE E2 CONSOLE

! CAUTION! A trained FEI Service Engineer or Authorized Supervisor must restart the system after an emergency power off.

What Happens during Power Failures

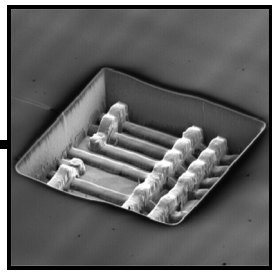
The system has protection against power failures in the sense that the different components of the system are not likely to be damaged. However, a power failure is never good for the system. It might affect the ultra-high vacuum levels of the columns and the overall stability of the system. Take sufficient measures to avoid power failures as much as possible.

If a power failure occurs during normal operation of the workstation, the system powers down to a safe status and the following happens:

- The specimen chamber vents.
- The column valves close so the high vacuum in the columns is not completely lost.
- The momentary adjustments of all the workstation parameters (high voltage, magnification, etc.) are lost if they have not been saved prior to the failure.

If the system was down less than 45 minutes it can be recovered according to the **Startup** procedure by an authorized supervisor. If the system has been off for a longer time a FEI trained service engineer may have to bring the workstation back into operation.

4 USER INTERFACE



This chapter gives an overview of the xT Control software for the Nova NanoLab and describes the functionality of each part of the user interface. It takes you from the first main window and menu bar through each item on the pulldown menus through to the pages. Graphics illustrating most of the choices help you locate specific features.

The software interface controls most system functions including milling, patterning, detection and analysis, scanning and magnification, image gathering, manipulation and output, stage and vacuum.

For more detailed information about Windows 2000, refer to the *Microsoft® Windows™ Users' Guide* shipped with your system.

Other Software and Hardware

Call Customer Service for advice before installing software or hardware that is not required for system operation. Other software, such as screen savers, or hardware network cards may corrupt the system control software under some circumstances and may invalidate warranty.

User Access Privileges

Multiple levels of user access are defined in the software. The user has full access to the instrument, except for any alignments. The supervisor has access to a set of supervisor alignments.

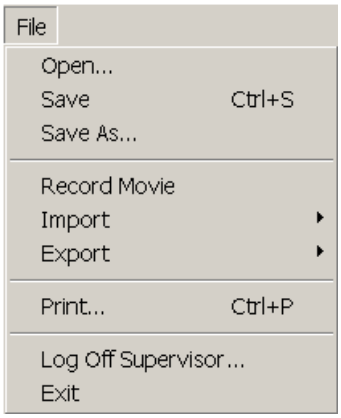
The pages found in this manual are Supervisor/User pages where the users are permitted to control general operation functions and but not advanced technical maintenance. Most technical maintenance is taken care of by a FEI SEM/FIB trained service engineer who has the rights to enter the system via a Service access level similar to the Factory level entry.

Software Interface Elements

Icon

A small symbol indicating a specific software application. For example, the software can be shrunk to an icon at the bottom of the screen. An application shown as an icon is running in the background of the computer memory. Double-click on the icon to restore the program.

There are also icons in the **Tool bar** for selecting system functions quickly (as seen on the left). Clicking on any of these will cause them to press in, when deactivated by clicking again they spring out.



Pulldown Menus

The microscope uses menu-oriented software; you perform functions by choosing items from the **Menu bar**. The Menu bar selections contain pulldown menus that display group listings of available commands or settings. Some menu items are shown in gray and cannot be selected. You might also get a beeping sound if you try to select unavailable functions.

Selecting with the Mouse

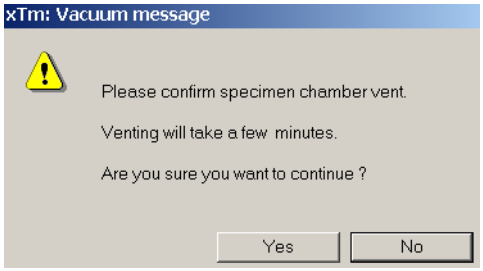
To select a pulldown menu, click on the menu item in the Menu bar, then drag the cursor down to the desired selection and release the left mouse button.

Pulldown menu selections followed by points (...) indicate a dialog box will display. Selections with a right arrow indicate an additional submenu of choices will display.

If the selected setting is a parameter value, the new value is updated immediately and a check mark appears in the pulldown menu. If the selected setting is a command, a new popup menu or dialog box appears.

Selecting with Keyboard Commands

To use keyboard commands for selecting top level menu items, press ALT plus the underlined letter (for example, ALT + D for the Detector menu), and then select from the choices with the left mouse button or with the up or down arrow keys.


xTm: Vacuum message
Please confirm specimen chamber vent.
Venting will take a few minutes.
Are you sure you want to continue ?
Yes
No

Dialog Boxes

A dialog box appears when the system needs more information from you before it can carry out a command. You can input information using text boxes, option buttons and command buttons.

Some dialog boxes do not let you access other functions until you exit the box. Other dialog boxes let you perform other tasks while they remain onscreen and active. For example, the Preferences dialog boxes can remain open while you do other tasks.

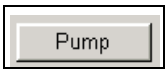
Radio Buttons

Use round option buttons to make selections. Within a group of related option buttons, only one selection can be active at any time.

Check Boxes

Use square check boxes to make selections. Single or within a group of check boxes, items can be switched on or off by clicking in the individual boxes. A ‘tick’ means ‘ON’ or active and an empty box means ‘OFF’ or inactive

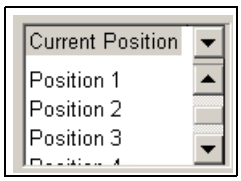
Command Buttons



Rectangular command buttons carry out a function. They press in when clicked on and some change colour to show activity. When reversing the function the button springs out. Command buttons have labels that describe the action. Examples: OK, CANCEL, APPLY, RESET

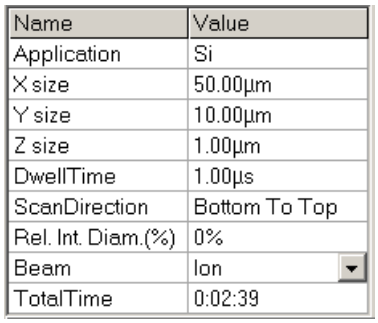
Click on OK to close the dialog box. The software updates all information shown in the dialog box. Click on CANCEL to quit the dialog box without updating the information. Click on APPLY to introduce the change immediately, but not permanent. click on RESET to restore default conditions.

List Boxes



List boxes contain available choices, such as Location settings. If a list box is too small to show all the selections, click on the up or down arrow in the vertical scroll bar or click and drag the slider to see more of the list.

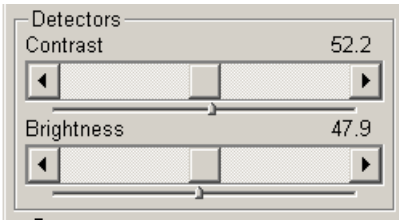
Property Editors



Name	Value
Application	Si
X size	50.00µm
Y size	10.00µm
Z size	1.00µm
DwellTime	1.00µs
ScanDirection	Bottom To Top
Rel. Int. Diam.(%)	0%
Beam	Ion
TotalTime	0:02:39

These are the same in structure as normal list boxes but text can be entered in as part of the listing. The entry space is white and the prohibited zones are shaded. The user should click in the VALUE side of the relevant property editor and then either type in the new value or select from the drop down list.

Continuous Control Adjusters

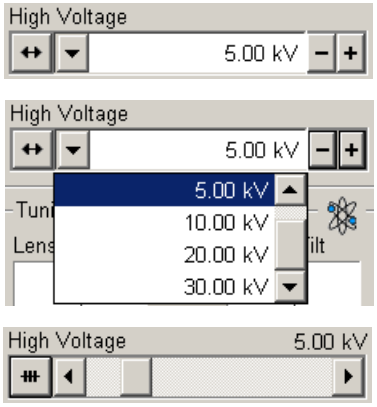


A continuous control adjuster allows you to change parameters, such as contrast and brightness, in a continuous way by clicking and dragging the middle slider or clicking in the gray bar.

- **middle slider**—for large or small adjustments. The further from left the middle slider is pulled, the larger the change.
- **gray bar**—for large adjustments, single step increments.
- **end arrow**— fine step increments.

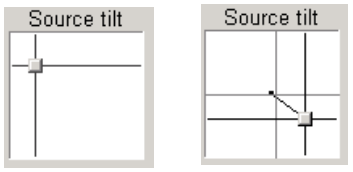
These adjusters always have a label in the upper left and right corners for readout information.

Preset/Continuous Control Adjusters



This special control is used for values that have both a continuous range and a list of presets, such as E-column HV. It is used on the **Beam Control** page. The button on the left side of the adjuster toggles between modes.

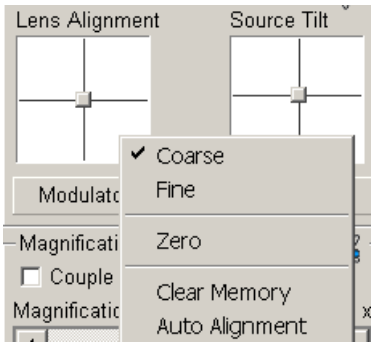
Two-Dimensional X-Y Controls

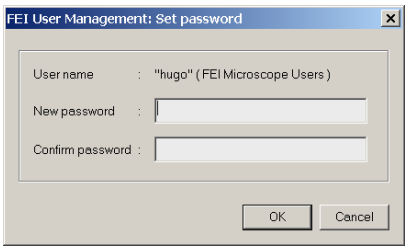


Ticked Unticked

These two-dimensional continuous controls are represented by an X-Y box. The position of the crosshair is related to the actual settings, the full range of the parameters being represented by the perimeter of the box.

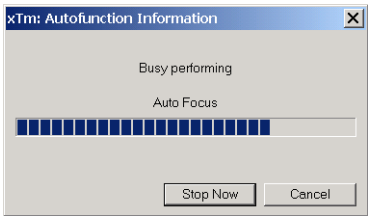
Click and hold down the left mouse button in the grid to display a crosshair in the image area. The cursor changes to a 4 axis cross and can be moved in four directions that correspond to the X, Y screen values. To fix the values, release the mouse button and the position of the crosshair updates.The sensitivity of the X-Y control can depend on the magnification chosen. At higher magnification, you may click on the center square with the right mouse button to open a dialog showing a choice of **Coarse, Fine, Zero, Clear Memory** and **Auto Alignment**. **Zero** will bring the 2D control to the center.





Text Boxes

Type information in a text box. This direct keyboard input is used to produce text such as filenames, passwords, user labels in the data bar, and specified values of certain parameters.



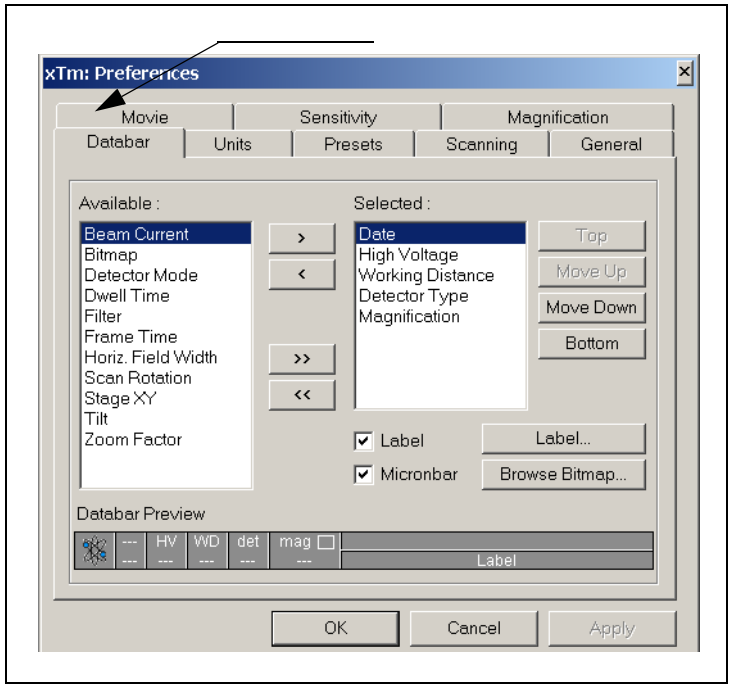
Progress dialogs

Progress dialogs indicate progress of a procedure over time by means of a progress bar.

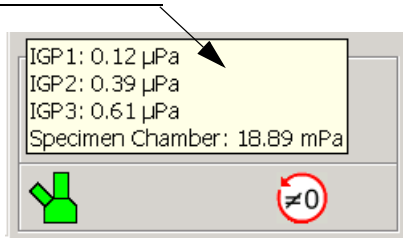
Tabbed Dialogs

Tabbed dialogs form either across the operating page or in a Quad (lower right). These can be alternately opened by clicking on the label along the top of the dialog area. Preferences and other conditions can be changed and stored in these dialogs.

FIGURE 4-1 PREFERENCES TABS

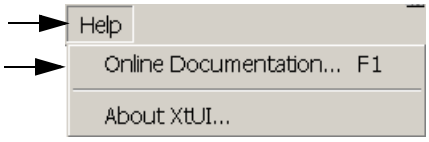


Help Functions



Tool-Tips

The first line help is integrated in the software as **Tool-Tips**. These are activated when the cursor is left over a item on the user interface for 2 seconds. A short explanation of the item will appear until the cursor is moved away from the item.



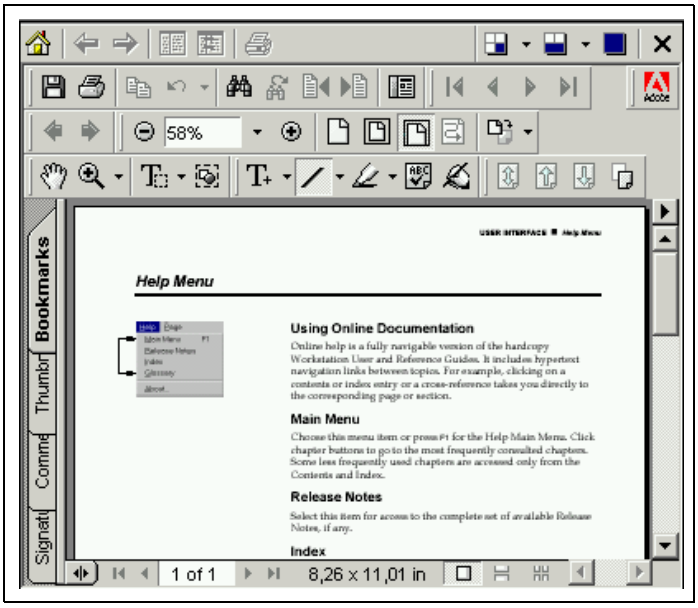
On-Line Documentation

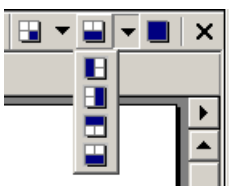
The On-Line Documentation function can be switched on by the F1 key on the keyboard or from the **Help** menu. The Help dialog area is defaulted to the bottom right Quad at startup, and can be expanded to all Quads for more detailed help including diagrams and images. It can also be dragged to any position on the available screen. The help box function remembers the position and size that the user last defined until defaulted on startup.

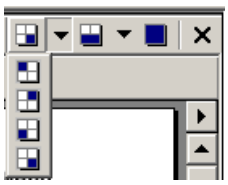
Hyperlinked Help

The opened Help pages have hyperlinks to subjects such as operation procedures, Tips and other useful information.

FIGURE 4-2 ON-LINE DOCUMENTATION.







Display controls

The On-line window can be placed in any quad or any half screen as well as full screen. This can be controlled from the listed buttons on the top right of the On-line window. These are useful if it is important to view the application at the same time. The On-line window can also be dragged to size and placed anywhere on the screen. The position of the window is remembered when the On-line window is recalled.

xT Control Interface Elements

The xT Control Interface Elements make up some or all of the application windows displayed when the xT Control software is loaded.

This consists of the following items:

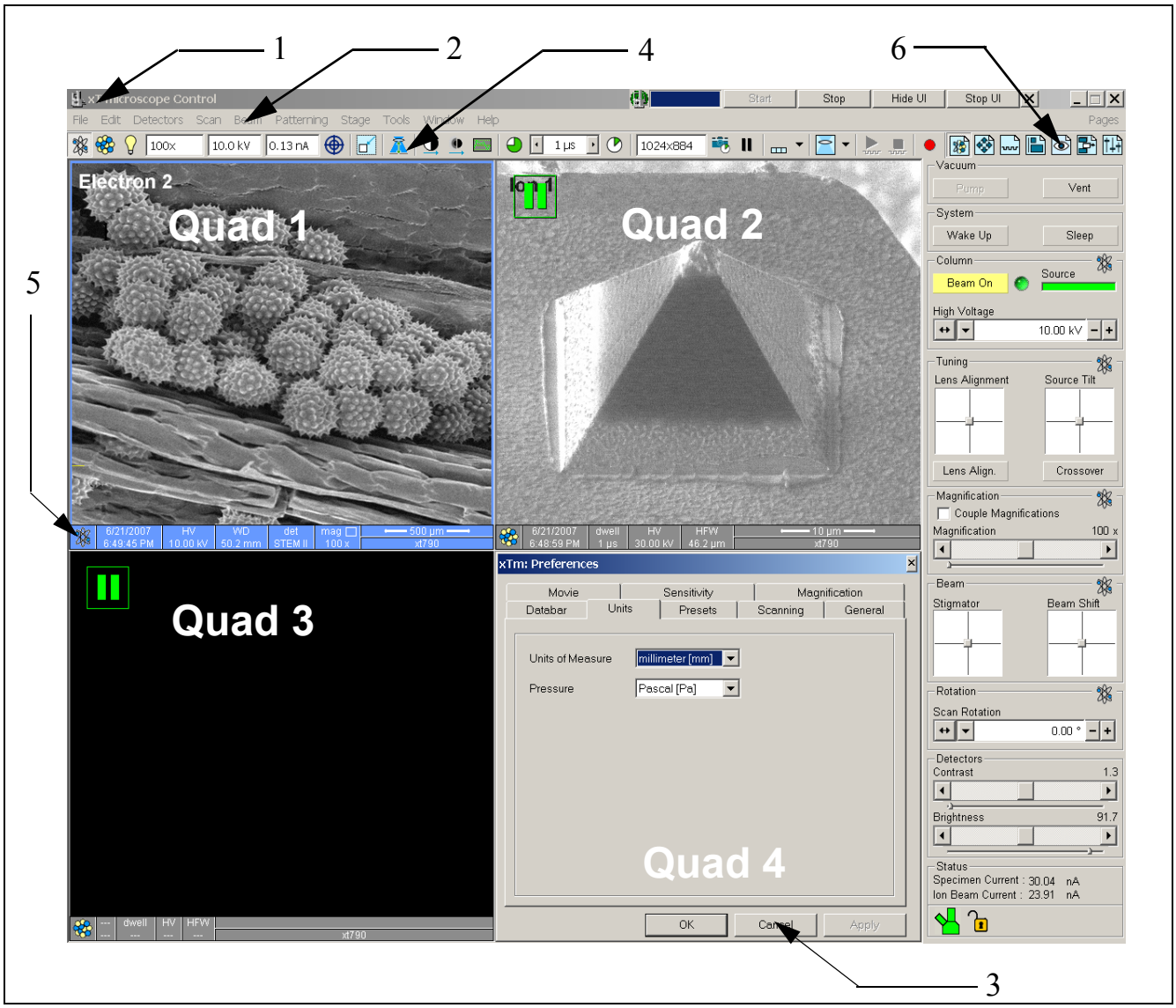
- **Main Window** - displays all interface elements
- **Title Bar** - labels the application and the owner/user
- **Menu Bar** - contains all operation menus and submenus
- **Preferences dialogs** - presetting of operating conditions
- **Tool Bar** - contains all iconised button functions
- **Pages** - contains all pages made up of one or more modules
- **Quad Image Windows** - 4 image windows providing independent image functionality modes
- **Main Image Window** - full single image mode
- **Data Bar** - contains all data information entered by preference for storage/printout of the image.

Control of some or all of these items is made via the mouse, keyboard or the Manual User Interface pad.

The Main Window

The **Main Window** displays status and control features for the Microscope Control, including the image window, application bar, menu bar, tool bar, data bar and pages.

FIGURE 4-3 THE MAIN WINDOW



Interface Elements

Some of the xT Control Interface main elements break down into other sub-menus or modules.These consists of the following items:

1. The Title Bar - labels the application and the owner/user

2. The Menu Bar - contains all operation menus and submenus:

- The File Menu
- Edit Menu
- The Detector Menu
- The Scan Menu
- The Beam Menu
- The Patterning Menu
- The Stage Menu
- The Tools Menu
- The Window Menu
- The Help Menu

3. Preferences... - opens in 4th Quad for presetting of operating conditions.

- DataBar
- Units
- Presets
- Scanning
- Magnification
- General
- Movie
- Sensitivity

4. The Tool Bar - contains all iconised button functions

5. The Data Bar - contains all data information entered by preference for storage/printout of the image.

6. Pages and Modules - contains all pages made up of one or more modules:

- Beam Control Page
- Navigation Page
- Patterning Page
- Processing Page
- Detector Page
- Sample Prep Page
- Alignments Page

7. Hardware Interface Elements (not shown here)

- Mouse
- Keyboard
- Manual User Interface (MUI) (Option)
- Joystick (Option)

The Title Bar

The **Title Bar** displays the logged on user name that was entered to log on Windows 2000 level.

FIGURE 4-4 THE TITLE BAR

The Menu Bar

The **Menu Bar** displays pulldown menus across the top of the screen below the Title Bar.

FIGURE 4-5 THE MENU BAR

Menu Bar Functions

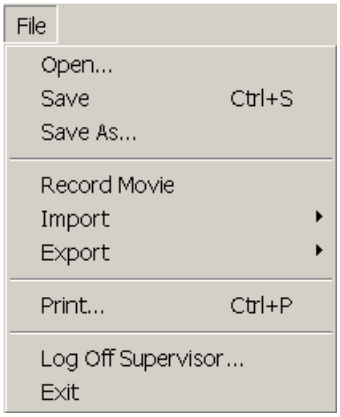
The following menus are available:

TABLE 4-1 MENUS

Menu Item	Use
File	Administrative functions.
Edit	Edit Pattern(s) such as delete or select all.
Detector	List of detectors.
Scan	Scan condition functions for Electron and Ion beams.
Beam	Choice of Beam conditions; Electron, Ion and Light, and controls.
Patterning	Patterning and deposition functions.
Stage	Stage navigation and corrective functions.
Tools	Image Auto functions.
Window	The image display functions.
Help	About Nova UI and On-line help.

Select pulldown menus from the menu bar by using either the left mouse button or ALT + letter from the keyboard.

File Menu



Clicking on the **File** name in the Menu bar, with the left mouse button, opens the **File** menu. This can also be achieved by pressing the **Alt**+**F** keys.

Open

Clicking on Open, with the left mouse button, opens a dialog for opening an image in the selected quad or a full screen. Images can be opened in TIF (8, 16 and 24 bit col or depth), JPG and Bitmap formats.

Save

Clicking on **Save**, with the left mouse button, saves the image with an incremental label at a predetermined location. This is also used when a restored image has been updated in any way, such as a LUT change and is necessary to overwrite the original. This can also be achieved by pressing the **Crtl** +**S** keys.

Save As...

Clicking on **Save As**, with the left mouse button, opens a dialog for saving an image. This provides an opportunity to change the label and save the same file, a new file, with a different label.

Record Movie

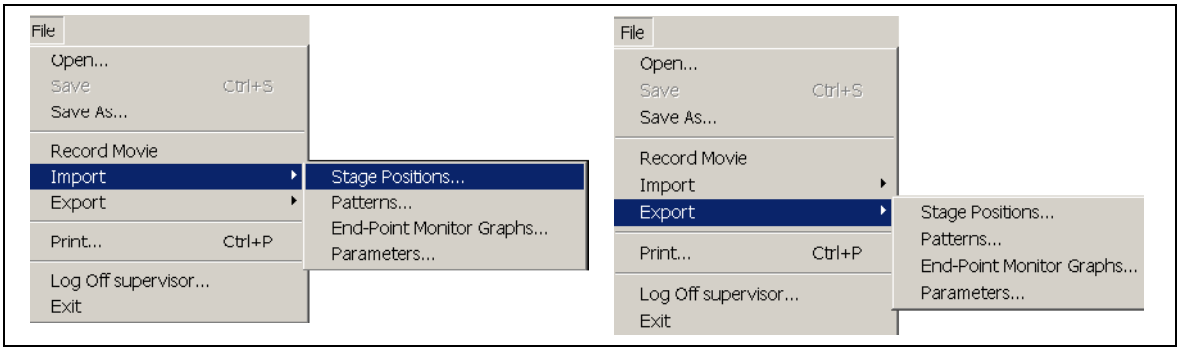
Clicking on **Record Movie** starts the recording of three videos, one for each of the three image quads at the same moment. If a quad is paused when starting the video, only the first image with a time stamp is stored. The red dot icon on the Tool Bar represents the same function When Record Movie is active the icon changes to a red square. Pressed it stops the movie function.

Import / Export

Access can be made to certain files produced by the FEI xT system. This in turn leads to an import / export dialog for selection.

STG files (Stage Positions), **PTF files** (Patterns), **EPM files** (End-Point Monitor Graphs) and parameters are available to Import / Export. When opening the file, parameters or data saved with it are restored.

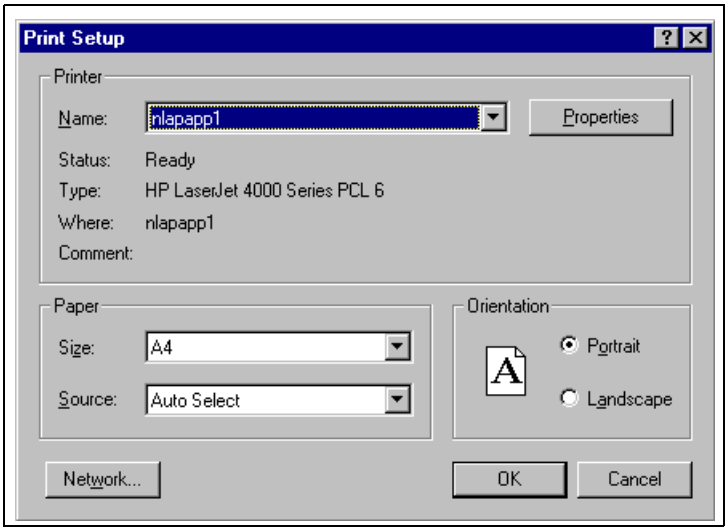
FIGURE 4-6 FILE IMPORT / EXPORT MENU



Print...

Clicking on **Print**, with the left mouse button, opens the printer dialog so that choice of printer and conditions can be established ready to print an image, or any other printable product from the microscope. This can also be achieved by pressing the **Ctrl** + **P** keys. Pressing **OK** in the printer dialog will activate the printer to print the job.

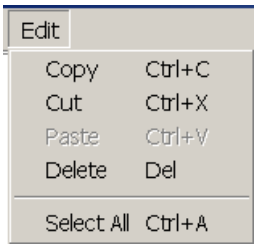
FIGURE 4-7 PRINTER DIALOG



Exit

Clicking on **Exit**, with the left mouse button, will exit the UI program and leave one in the operating system environment with the Server still running. This can also be achieved by pressing the **Alt** + **X** keys. To activate the UI again one would have to click on Start UI in the Server bar.

Edit Menu



Clicking on the **Edit** name in the Menu bar, with the left mouse button, opens the **Edit** menu. This can also be achieved by pressing the **Alt**+**E** keys.

The **Edit** menu is for copying, cutting, pasting or deleting patterns. There is also a select all function for multiple processing.

Copy

Copy an existing pattern.

Cut

Cut an existing pattern from one quad to paste in another.

Paste

Paste a pattern from memory into the existing quad or another.

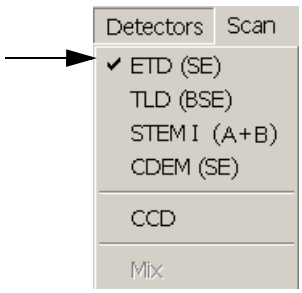
Delete

Delete a pattern.

Select All

Select all patterns in a quad.

Detectors Menu



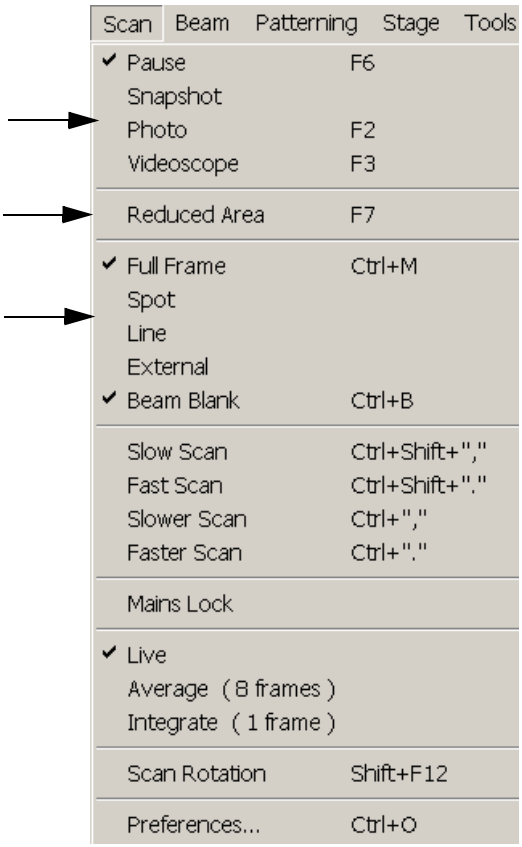
Clicking on the **Detector** name in the Menu bar, with the left mouse button, opens the Detector menu. This can also be achieved by pressing the **Alt** + **D** keys.

Detector list

This list contains various detectors for E-Beam and I-Beam operation. Depending on the beam mode in operation only the relevant detectors will appear in black. All others will be grayed out. Only the selected detector will show a tick next to it's label.

Customizing or choosing preferences for different detectors can be found on the Detector Page.

Scan Menu



Clicking with the left mouse button on the **Scan** name in the menu bar, opens the scan menu. This can also be achieved by pressing the **Alt** + **C** keys.

Pause

Click on the **Pause** function to pause the image. Click once and the scan will stop immediately without finishing the frame. When Pause is active clicking again will release the pause function and return the scanning to the original condition prior to pause. The Pause icon button on the Tool bar has the same functionality. It can also be activated by **F6**.

Snapshot

Clicking on **Snapshot** at any time will activate a preset scan.The result can be stored on the harddrive automatically to a predetermined directory using the next available label/number (same as Save destination). If the Save or Save As function is not set in **Preferences** the image is only retained onscreen by the Pause function. Unpause to start scanning. Snapshot can also be activated from the Tool Bar.

Snapshot for the Electron beam can be activated by function key **F4.**

Snapshot for the Ion beam can be activated by function key **Crtl + F4.**

Photo

Clicking on **Photo** at any time will activate a preset higher resolution slow scan.The result can be stored on the harddrive with the **Save** command, in the **File menu**, by using the next available label/number in a predetermined folder. **Save As** can be used if the Folder and label need to be changed prior to saving. Photo can also be activated by **F2**.

Videoscope

Videoscope toggles the display of the videoscope on or off, showing the video intensity along the currently scanned horizontal line. It can also be activated by **F3**.

Reduced area

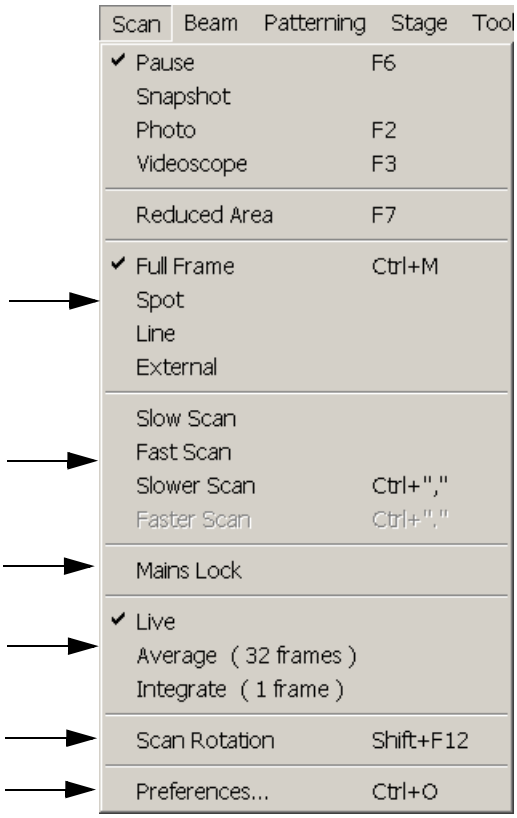
When **Reduced area** is chosen, the reduced area appears with the same dimensions and at the last known place on the screen. On activation it restores the last used scan condition. Scan condition can be changed if necessary. Can also be activated by **F7**.

Full Frame

Full Frame is the default scanning mode. This is the normal scanning mode, typical for general navigation.

Spot

Clicking on **Spot** puts you in Spot mode and allows one to move the beam around the screen with the left mouse button pressed. The spot position is represented by a green cross.



Line

When **Line** is selected from the Scan menu, the image freezes and a green horizontal line displays on the screen. The beam scans along this line, using the line time defined for the selected scan speed. When you choose Line, the cursor changes to an arrow. Move the cursor to the desired vertical position and click the left mouse button.

External

External is a switch to activate external control of the scanning system, such as beam control from an EDX X-ray system.

Slow Scan

Clicking on **Slow Scan** will bring the scanning condition to the preset value, held in the Preferences/Scan dialog.

Fast Scan

Clicking on **Fast Scan** will bring the scanning condition to the preset value, held in the Preferences/Scan dialog.

Slower Scan

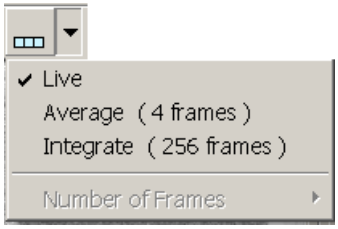
Clicking on **Slower Scan** will bring the scanning condition to the next slower scan value held in the Preferences/Scan list dialog. This can be also achieved by pressing **Crtl** + "**,**".

Faster Scan

Clicking on **Faster Scan** will bring the scanning condition to the next faster scan value held in the Preferences/Scan list dialog. This can be also achieved by pressing **Crtl** + "**.**".

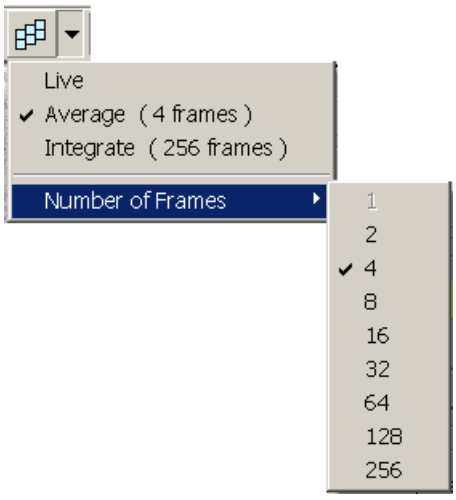
Mains Lock

Clicking On **Mains Lock** will synchronize the mains frequency to the Scan system.



Live

With **Live** selected, the image remains unfiltered for collecting direct images, mostly in Live/Slow scan.



Average

Select **Average** to continuously average a specified number of frames, selected from the list, resulting in a better signal-to-noise ratio. This is used mostly in a fast scan mode to reduce noise in fast scanned images. During averaging, the image is updated continuously and actions such as focusing, moving the stage, etc. can still be performed. The number of frames can be selected as a preset from the Tool bar drop down list box associated with the Average function.

Integrate

The **Integrate** feature allows accumulative noise reduction by true integration over a number of frames, selected from the list, and freezes the final image. During and after image accumulation, you cannot change the focus or perform other image-influencing actions. The number of frames can be selected as a preset from the sub menu or from the Tool bar drop down list box associated with the Integrate function.

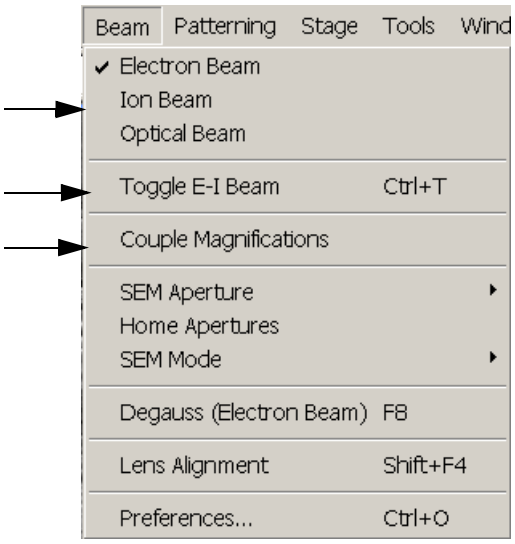
Scan Rotation

Clicking on **Scan Rotation** activates the onscreen tool to rotate the scan and align the image. It has no effect on the stage movements and is solely a scan coil function but is used to orientate the image relative to mechanical rotation and detector direction. It can also be activated by **Shift** + **F12**.

Preferences...

Clicking on **Preferences...** opens the total preferences dialog. Scan choices can be found under the tab labelled '**Scan**'.

Beam Menu



Clicking on the **Beam** name in the Menu bar, with the left mouse button, opens the Beam menu. This can also be achieved by pressing the **Alt** button and the **B** key.

Electron Beam

Clicking on **Electron Beam** will make the Quad or single screen active to the electron beam with respect to source, column, scanning, and detectors.

Ion Beam

Clicking on **Ion Beam** will make the Quad or single screen active to the ion beam with respect to source, column, milling, scanning, and detectors.

Optical Beam

Clicking on **Optical Beam** will make the Quad or single screen active to the optical beam with respect to Source, and detector.

Toggle E-I Beam

Clicking on **Toggle E-I Beam** will allow moving from one beam operation to the other and visa-versa. This can also be achieved by pressing Ctrl+T on the keyboard.

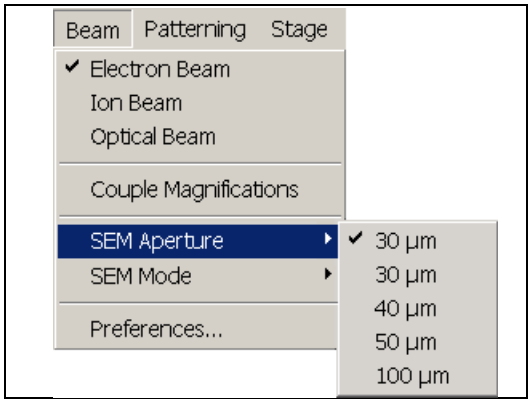
Couple Magnifications

Clicking on **Couple Magnifications** will allow the Electron and Ion columns to be coupled together, so that when switching between columns there is no difference in magnification.This is particularly useful when milling with the Ion Beam and viewing with the Electron Beam.

SEM Aperture

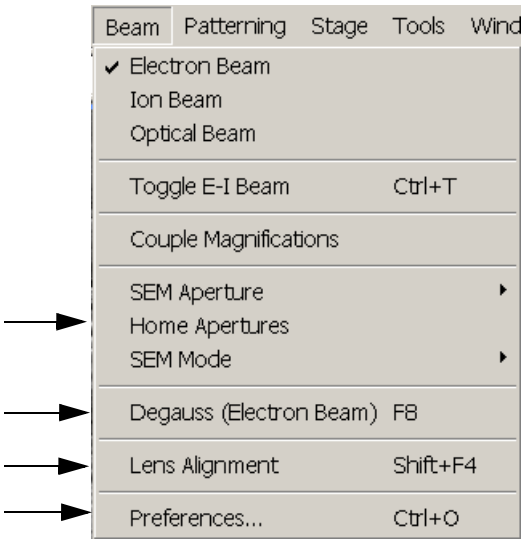
The SEM column final aperture can be selected by clicking on **SEM Aperture** in the Beam menu. A secondary dropdown menu appears with a selection of aperture sizes. For correct correlation the aperture selected in this menu should correspond to the physical SEM aperture selected.

FIGURE 4-8 SEM APERTURE SELECTION



Home Apertures

Home Apertures sends the steppermotors of the FIB Aperture Mechanism back to its home position.



SEM Mode

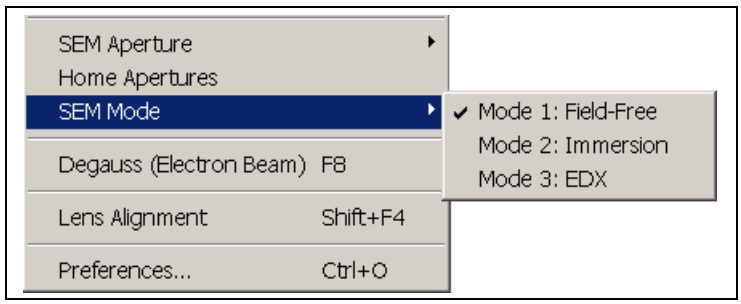
By clicking on **SEM Mode** the following two modes of image resolution are available for use with the E-Beam:

Mode 1 (Field Free)

Mode 2 (Immersion)

Mode 3 (EDX)

FIGURE 4-9 SEM MODE SELECTION



Either mode has its own E-Beam and magnification presets and are editable in the Tool Bar dropdown list or the Preferences E-BEAM Tab. Use the Tool Bar buttons to switch between modes.

Degauss (Electron Beam)

Degauss triggers the degauss procedure appropriate for the current SEM Mode. The procedure puts all currently used electron lenses in a normalized state by removing their hysteresis effects. For a few seconds while the procedure is running all live images disappear or turn fuzzy, and than returns back. Use this function with (almost) focused image to obtain the most accurate Magnification, HFW and Working Distance readouts.

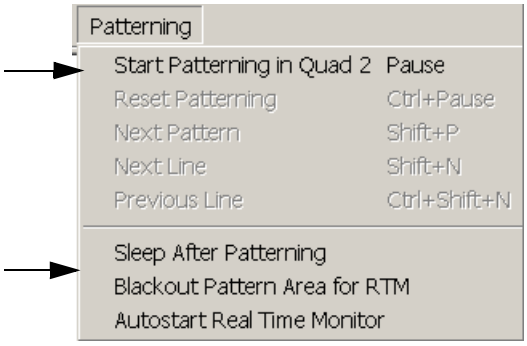
Lens Alignment

This is dedicated to the electron column. Lens Alignment toggles lens alignment mode on the Beam Page for the objective lens fine alignment. The scanning condition changes to a fast scan, and the lens modulator turns on, a green target cross appears in the center of all SEM image Quads. Pressing and holding the left mouse button activates a quad arrow ended cursor. Dragging the mouse aligns the beam with respect to the objective lens with the purpose of reducing the movement swing. This in turn eliminates or reduces the movement during focusing.

Preferences...

Clicking on **Preferences...** opens the preferences dialog at the Beam Tab.

Patterning Menu



This is the menu for executing Patterning.

These items in the **Patterning Menu** are command functions and change according to the function operating at the present time. They also follows the trend of the Tool Bar buttons and Pattern Page.

Start Patterning (in Quad #)

Click on **Start Patterning** to begin patterning with the pattern selected on the Patterning Page. After the command will appear the Quad number use for patterning and after that the status, such as **Pause**. Click on **Pause** to temporarily stop patterning, click again to **Unpause** and to continue.

Reset Patterning

Click on **Reset Patterning** to reset patterning to the beginning of the pattern procedure once again. Press Ctrl+Pause

Next Pattern

Next Pattern will be available if multiple patterns have been drawn. Click on Next Pattern to stop milling the current pattern and continue with the next pattern. Also can be activated on the Pattern Page. Press Shift+P.

Next Line

When the cleaning cross-section is used **Next Line** will be enabled. Click on next line to stop milling the current line and continue with the next line. Also can be activated on the Pattern Page. Press Shift+N.

Previous Line

When the cleaning cross-section is used **Previous Line** will be enabled. Click on next line to stop milling the current line and continue with the next line. Also can be activated on the Pattern Page. Press Ctrl+Shift+N.

Sleep After Patterning

Sleep After Patterning activates the **Sleep** command (from Beam Control page) when the patterning process finishes.

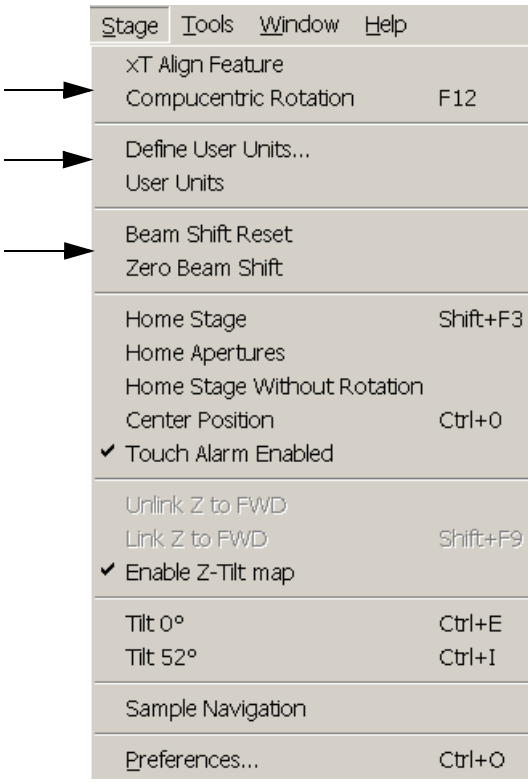
Blackout Pattern Area for RTM

This function blacks out the pattern background where the RTM is displayed. It is made black in order to enhance the visibility of the RTM information.

Autostart Real Time Monitor

Click on **Autostart Real Time Monitor** for the RTM to automatically start when patterning starts.

Stage Menu



Clicking on the **Stage** name in the Menu bar, with the left mouse button, opens the Stage menu. This can also be achieved by pressing the **Alt** + **S** keys.

xT Align Feature...

Clicking on **xT Align Feature** starts a procedure that helps one to orientate a linear feature to either of the stage movement directions; X or Y.

Compucentric Rotation

Clicking on **Compucentric Rotation** in the Stage Menu places a green circle in the active quad. By rotating the circle a different viewing orientation of the sample area can be achieved. This is compucentric stage rotation. It can also accessed by **F12** or on the Stage Page / Coordinates Tab.

Define User Units...

Clicking **Define User Units** on activates a series of dialogs that guide the user to determine User Unit values for X and Y movements of the stage. These are used in relative movements associated with stage mapping of regular features, in particular in IC applications.

Offset Alignment

Offset Alignment is a shortcut that allows you to move to new points relative to the existing alignment but at a new location, for example, stepping between identical points on different dies quickly.

User Units

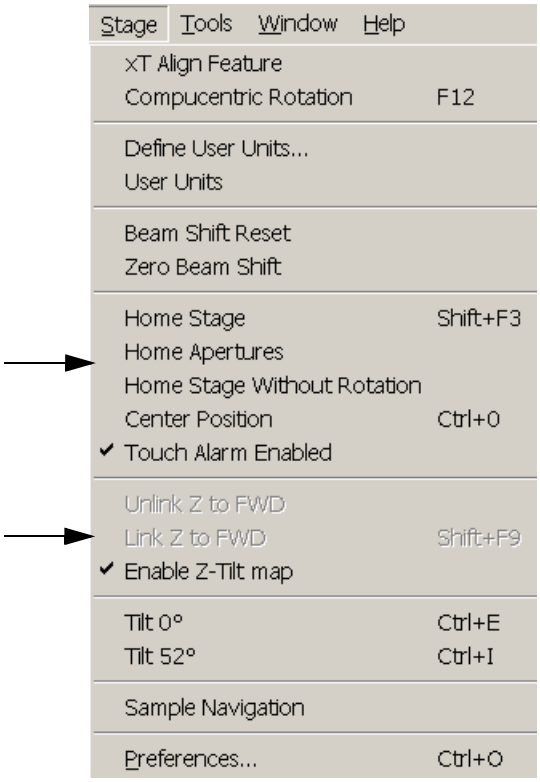
Clicking on **User Units** organises the stage software to recognise the defined user units rather than the default metric measurements. The X and Y coordinates now operate in User Units and is shown in the Location module by the UU symbol.

Beam Shift Reset

Use this function to begin the **Beam Shift Reset** procedure to zero beam shift and move the feature to the center of the field of view with the stage.

Zero Beam Shift

When beam shift has reached maximum limits, choose **Zero Beam Shift** to restore X and Y beam shifts to zero values. The computer beeps when maximum limits are reached.



Home Stage

Clicking on **Home Stage** will open a dialog to define the influential conditions, and by pressing YES the Stage will home. When the stage is homing the Stage Active dialog box flashes onscreen. When the stage is homed correctly, the end position will be the last Reference position stored.

Z = preset long working distance relative to stage type.

It can also accessed by **Shift** + **F3** keys.

Home Apertures

Home Apertures sends the steppermotors of the FIB Aperture Mechanism back to its home position.

Home Stage Without Rotation

This function is to perform Home Stage function without rotating of the stage. When the stage is homed without rotation, the stage reference for Rotation is greyed out. This is useful when a large specimen is inserted and stage rotation could cause a collision with equipment inside the chamber. By default the function is enabled and automatically reverts back to the enabled status after every venting / pumping cycle.

Center Position

Moves the stage to coordinates X = 0, Y = 0, which is the central position.

Touch Alarm Enabled

This function automatically stops the stage movement and displays Touch Alarm warning dialogue whenever the stage or a conductive specimen touches the Immersion lens or any other equipment conductively connected to the chamber.

UnLink Z to FWD

Clicking on Unlink to FWD will display height (z) as a value corresponding with the distance from the z home position.

Link Z to FWD

Sets the Z coordinate value to actual Free Working Distance (FWD) value. This allows accurate movement between the known height of the sample and the end of the Immersion lens.

NOTE: The related toolbar icon image changes according to the Z-coordinate status.

FIGURE 4-10 ICONS FOR LINKING Z TO FWD

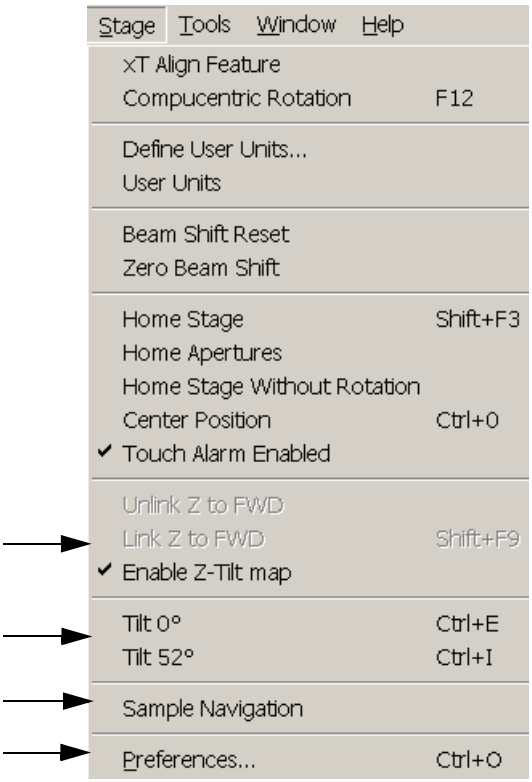
Greyed icon: the function is disabled because either the stage has not been homed or the HV is switched off (so there is no SEM image), or the Ion Beam is selected.

Red question mark: the function is enabled and the link between Z

and FWD is unknown. Use the function as soon as possible, after properly focusing the image.

Red circle: Z is roughly linked to FWD, but it needs correction. The function is enabled. It happens e.g. after: changing the specimen, focusing and linking Z to FWD at a long Working Distance and then moving the stage to a short WD. Focus image carefully at a WD around 5 mm and use this function again.

Green double-ended arrow: Z is properly linked to FWD. Now it should be safe to change the Working Distance by setting a Z coordinate in the Stage module. The function is still enabled to allow further corrections of the Z-coordinate.



Enable Z Tilt map

Some movements of the stage are illegal because of possible collision with the end lens. In a z-tilt map, a number of z-tilt value pairs indicate the maximum tilt angle for a certain z when coupled. A legal move of the tilt axis depends on the position of the z axis. The relation between the extreme positions of tilt and z indicate the extreme allowed positions. This relation is called the z-tilt map and can be used to guarantee safe usage of the stage.

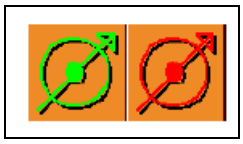
Tilt 0° (Ctrl + E)

Tilt 52° (Ctrl + I)

Sets stage tilt to 0° / 52°, perpendicular to Electron / Ion Beam respectively.

Sample Navigation

Toggles on / off function that enables to navigate live SEM images (scan field) towards desired places on a specimen using either paused or loaded image of that specimen (usually taken at much lower magnification).



The Sample Navigation can be selected independently for any Quad, regardless of its current content and status. A tick next to the menu item indicates that the function is selected for the active Quad. As soon as this Quad is paused, the Sample Navigation indicator appears in the upper right corner of the Quad. The indicator is green as long as the paused image can be used to navigate the live images, otherwise turns read (e.g. when the stage rotation or tilt changes).

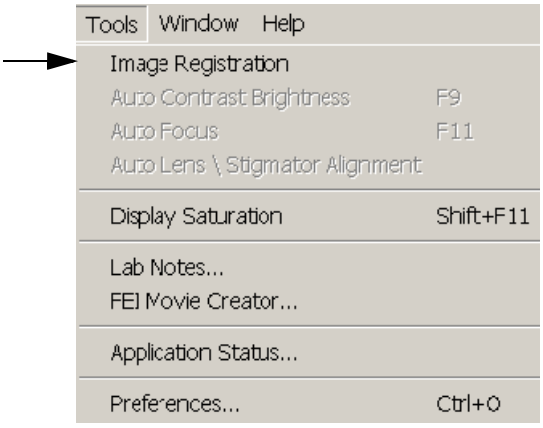
(See Chapter 5 for a detailed description.)

NOTE: To make sure this function working properly, the stage rotation value for captured image and corresponding live images are the same.

Preferences...

Clicking on **Preferences...** opens the preferences dialog.

Tools Menu

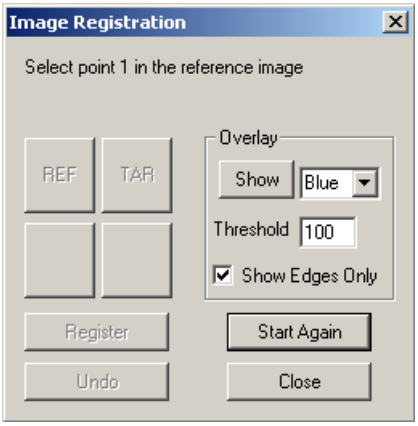


Clicking on the **Tools** label in the Menu bar, with the left mouse button, opens the Tools menu. This can also be achieved by pressing the **Alt** + **o** keys.

Image Registration

With user-specified alignment points, the user can transform one image spatially to correspond to another image, then mill on that new image as if it were an image of the sample. The transformed image could include one taken with the optical microscope that corresponds to the real sample, or several taken at various depths of focus. This is also called *image-to-image registration* and *image alignment*.

Click on **Image Registration** and follow the prompts in the dialog box that appears. The user first selects the quad with the reference image and then the quad with the target image (this is the one that will be transformed). After this a single or multipoint alignment can be applied by selecting similar points in both the reference and target image. **Register** will apply the transformation after 1, 2 or 3 pairs of points have been selected. See TABLE 6-7 (Alignment Type Difference) for a description of when to apply each time of alignment.



Register will re-apply the registration on any new or restored image in the same or a different quad. When **Show** is selected from the overlay panel a copy of the registered target image will be shown on the reference image which shows the quality of the registration and to allow information from both images to be used in placing patterns. The overlay can be shown in red, green or blue. The **Threshold** value (0 to 255) determines which gray levels of the target image are shown in the overlay.

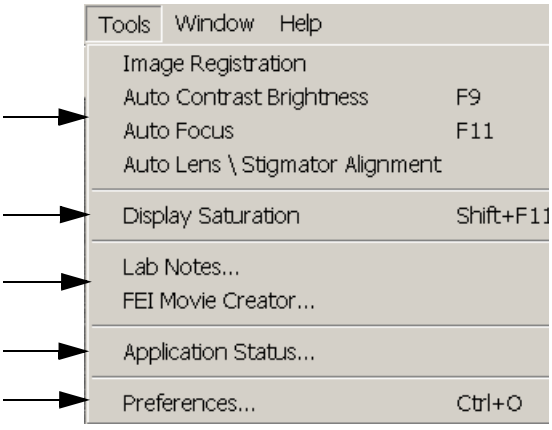
After registration the micron bar and magnification of the target image take on the same values of the reference image. Any operation that is applicable to an acquired FIB/SEM image can be applied to a transformed image, including creating and milling patterns and saving to a file.

Tips on Using Image Registration

Additional considerations include the following:

- Use images of similar magnification. In general, magnification needs to be as high as possible, with obvious limits for images taken with the optical microscope.
- Select Quad-Image mode before beginning.
- Image alignment, particularly 3-pt, is error-sensitive. Use care in selecting the corresponding features as precisely as possible.
- Use the crosshairs to make selections.
- Change to Single-Image mode for maximum enlargement while selecting the features for alignment.
- Use alignment points as far apart as possible, such as at the outer edges of the image.
- If possible, use points that are equidistant and orthogonal.

- After alignment, mill or deposit on the imported image or on the composite overlay image. Alternately, mill cross patterns briefly to mark the positions of buried structures so they are readily apparent during imaging.



Auto Contrast Brightness

Click on **Auto Contrast Brightness** to activate the automatic contrast and brightness routine. Can also be activated by pressing **F9**, or the Icon button on the Tool Bar.

Autofocus

Click on **Autofocus** to activate the automatic focus routine. Can also be activated by pressing **F11**, or the Icon button on the Tool Bar.

Auto Lens \ Stigmator Alignment

Click on **Auto lens\Stigmator Alignment** to activate the automatic Lens \ Stigmator correction routine.

Display Saturation

Click on Display Saturation to view the saturation status of the image. Oversaturated areas of the image (white areas) are shown in blue and undersaturated areas (black areas) are shown in yellow. Can also be activated by pressing **Shift** + **F11**

Lab Notes

Opens the Windows NotePad application above Quad 4 for the user to make immediate notes and remarks. After entry of a note the file can be stored as a text file (.TXT). Any previous note can also be opened in **Lab Notes**.

FEI Movie Creator

Provides a tabbed dialogue above Quad 4 for setting up a collection of sequenced TIF images, and sequencing them into an AVI movie. See Chapter 5 for a detailed description. This utility is installed also on the **support computer**, which enables to create a movie without influencing the **microscope controller** operation.

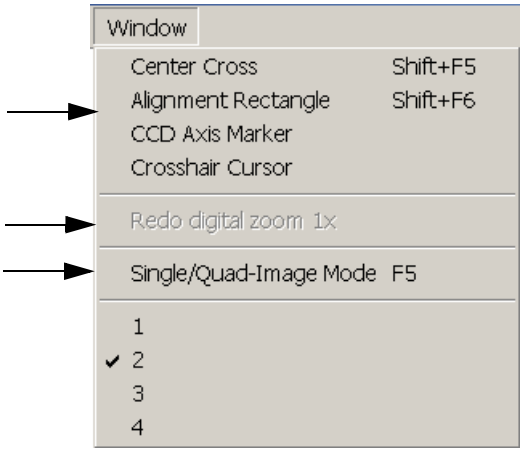
Application Status

Clicking on **Application Status** opens a dialog in the 4th Quad displaying a continuously updating status of the system.

Preferences..

Clicking on **Preferences..** displays the preferences dialog.

Window Menu



Clicking on the **Window** name in the Menu bar, with the left mouse button, opens the Window menu. This can also be achieved by pressing the **Alt**+**W** keys.

Center Cross

Clicking on **Center Cross** places a cross in the center of either the single screen or each quad depending on the display mode selected. This can also be achieved by pressing **Shift+F5** keys. This function is used in the Adjustment procedures to aid centering of features.

Alignment rectangle

Clicking on **Alignment rectangle** places a staggered rectangle in the center of either the single screen or each quad depending on the display mode selected. This can also be achieved by pressing **Shift+F6** keys. This function is used in the Adjustment procedures to aid controlling illumination.

CCD Axis marker

Displays x, y, and z axis in the CCD quad.

CrossHair cursor

Clicking on **Crosshair cursor** changes the mouse cursor into a crosshair cursor. The crosshair cursor is useful for aligning patterns or features.

Redo digital zoom 1x, 2x, 4x, 8x

Digital zoom can be set from the **Measurement and Annotation Page** by increasing or decreasing the magnification for the active image/Quad. **Redo digital zoom** retains the last magnification factor set by Digital zoom and when clicked on will set the magnification factor in the active Quad to that stored.

Undo digital zoom

When the Redo digital zoom has been activated the label in the Window menu reverts to **Undo digital zoom**. Clicking in Undo digital zoom brings the image back to normal magnification by negating the factor created by **Digital zoom**.

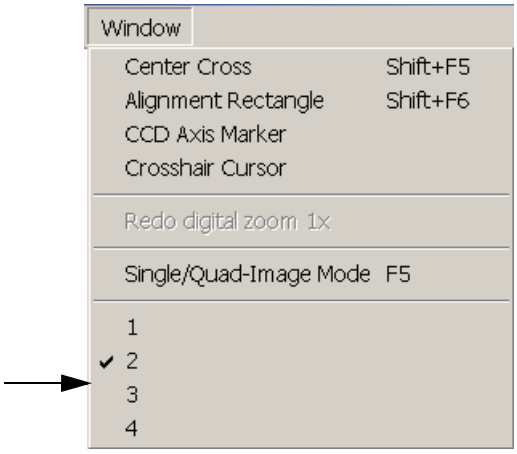
Single-Image / Quad-Image Mode

Single-Image / Quad-Image mode toggles the image display area from a single screen to a quad screen and vice-versa. It can also be activated by pressing **F5**.

In Single-image mode the quad list is selectable to be displayed individually in the single image mode. When you switch from Quad-Image mode to Single-Image mode, the active quadrant is the one that becomes full screen.

Quad-Image mode is useful for comparing images of the same sample area setup with different beams, detectors or scan properties.

Quads 1 to 4



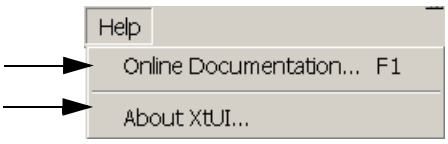
A Quad (1 - 4) can be selected from the **Window** menu by ticking the respective number. All Quads can contain live images. Quad 1 is top left and Quad 4 is bottom right with the others running horizontally. The Status of the Quad is also defined by the Beam type and whether it is paused or not. The active Quad also displays the beam icon with a light square background.

Only one image window has focus at any time, although the others can have live images. Quads can contain frozen or restored images.

Quad 4 is dedicated to various specific uses such as the CCD camera, Preferences and Online Help, but can contain an active image otherwise.

NOTE. The exception of detector in compatibilities, for example, BSD being incompatible with CCD will be the only restriction of the system of Beam/Detector per Quad.

The Help Menu



Clicking on the **Help** name in the Menu bar, with the left mouse button, opens the **Help** menu. This can also be achieved by pressing the **Alt** button and the **H** key.

Online documentation...

Clicking on **Online Documentation** displays in the right-lower quadrant the paging for the On-line function. This can also be activated by pressing F1 in the function key area of the keyboard.

About xTUI...

When clicked on this item displays the software version and date of release.

Setting Preferences...

The preferences dialog can be activated by selecting **Preferences...** at the end of any of the following menus: Scan, Beam, Stage and Tools.

The exception to this is the Preferences attached to the Detector menu which handles individual choices of Detectors with direct dialog.

The Preferences Dialogs

The background settings for day to day operation can be made by changing characteristic in any of the tabbed dialogs found in the **Preferences...** at the end of the above menus.

It will depend on the opened menu where Preferences... is chosen that dictates the tab opened on entry to the **Preferences dialog**. Once the Preferences dialog is opened any of the tabs can be chosen. Only one tab can be opened at any time.

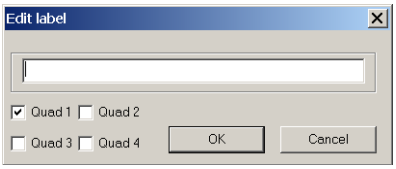
TABLE 4-2 TABBED PREFERENCES

Tab	Settings
DataBar	Selection of items for entry on the Databar.
Units	Selection of Units for Size, Temperature, Pressure, etc.
Presets	Entry for default lists of Magnification and High Voltage.
Scanning	Selection of presets for the scan speed defaults found on the Tool Bar.
General	Setting of the user interface behaviour
Movie	Set-up dialog for making movies.
Sensitivity	Fine adjustments for the Manual User Interface (MUI)
Magnification	Select working Screen, File and Print magnifications.

DataBar Tab

The **DataBar** Tab contains two lists, one labelled AVAILABLE and the other SELECTED. Items in the Available list can be added individually or as a whole to the Selected list. The Selected list, when completed, contains all items that will be displayed in the DataBar at the base of the imaging screen or screens. The order of the items in the Selected list can be moved up or down due to priority or preference. This will in turn change the order of the displayed items in the DataBar. Items can be removed from the Selected list singularly or in total back to the Available list.

The MICRON BAR will scale to the magnification but also will change size to accommodate other items added to the DataBar. It can be chosen also from the Available list.



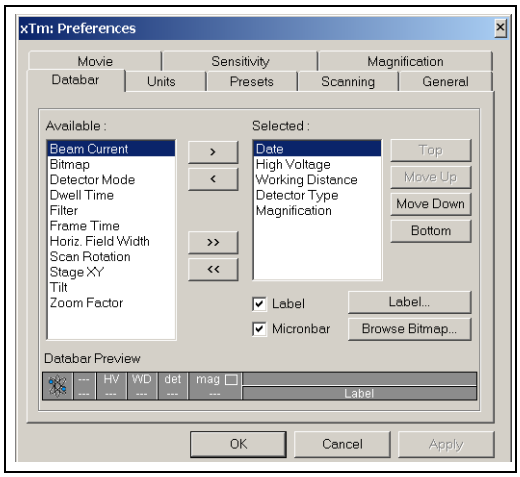
The LABEL (area) expands or contracts depending on the other items on the Databar. It can be chosen also from the Available list.

The label is edited another way. By clicking on the LABEL button a choice dialog appears to edit and copy the label to any of the other quads.

Clicking on the BITMAP button will open a dialog to load a bitmap into the databar.

The limit for entries is displayed in the dialog as it is updated.

FIGURE 4-11 DATABAR PREFERENCES



Click on the OK button to bring the new settings into operation, or CANCEL to return to the original setting. Either of these will close the **Preferences dialog**.

Click on APPLY to suspend the closing of the **Preferences dialog** but save the settings if one needs to move to other Tabbed dialogs to change further settings. When finished click on the OK button.

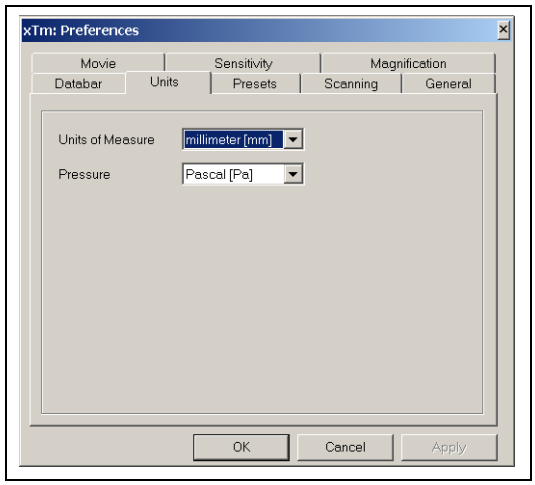
The Items chosen from the Preferences Tab dialog for the working DataBar will remain with the operating system until changed.

Units Tab

The **Units** Tab displays the capability to change the units for pressure, temperature and measure. The xT system will from time to time need to display values of PRESSURE. Units of Pascal, Torr, or Bar can be selected to suit. By clicking on the list arrow a selection can be made for the respective unit of pressure.

The UNITS OF MEASURE can be selected from the list by clicking on the list arrow and choosing the unit. The list contains meter and millimetre.

FIGURE 4-12 UNITS PREFERENCES



Click on the OK button to bring the new settings into operation, or CANCEL to return to the original setting. Either of these will close the **Preferences dialog**.

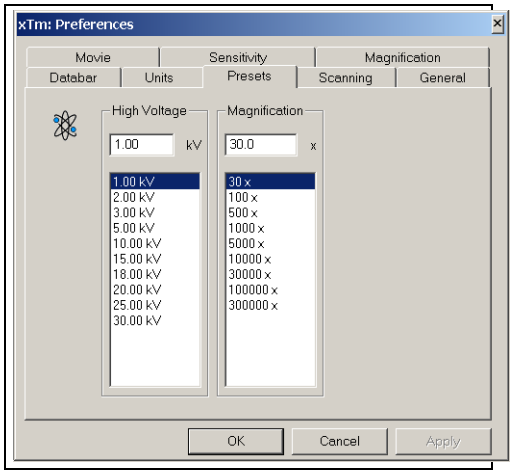
Click on APPLY to suspend the closing of the **Preferences dialog** but save the settings if one needs to move to other Tabbed dialogs to change further settings. When finished click on the OK button.

The Items chosen from the Preferences Tab dialog Units will remain with the operating system until changed.

Presets Tab

The **Presets** tab displays the capability to change values in the High Voltage and Magnification ranges either the Electron or Ion column. Either single or numerous values can be inserted in the lists. Changing values can be accomplished by entering values in the edit box just below the respective title.

FIGURE 4-13 PRESETS PREFERENCES



The HIGH VOLTAGE list can be changed to span any values from 200V to 30kV. As the values are displayed in Volts the entry value in the edit box can be specific in value.

The MAGNIFICATION list can be changed to hold regular used values or general values. Magnification values that are in the list but do not apply because of the Working distance condition will be grayed out in the Magnification menu on the Menu Bar. Magnification range is from 28x to 2.8Mx.

Click on the OK button to bring the new settings into operation, or **Cancel** to return to the original setting. Either of these will close the **Preferences dialog**.

Click on APPLY to suspend the closing of the **Preferences dialog** but save the settings if one needs to move to other Tabbed dialogs to change further settings. When finished click on the OK button.

The Items chosen from the Preferences Tab dialog Presets will remain with the operating system until changed.

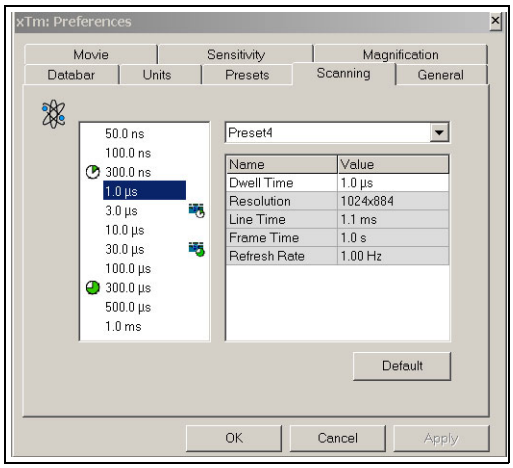
Scanning Tab

The **Scan** tab displays the capability to change scan times and make presets to the slow and fast scan buttons on the Tool bar for the beam selected. On the left of the dialog box there is a SCAN SELECTION list. There are two icons which correspond to the ‘Fast’ and ‘Slow’ preset button. The list of dwell times has a fixed number of entries. By selecting a scan icon the dwell time can be changed or edited in the DWELL TIME property editor for that scan function. The Fast and Slow icons indicate which value corresponds to the preset Icon buttons on the Tool Bar.

Scan Selection

The **Fast** or **Slow** icons in the Scan Selection module can be dragged to a new value to select that value, the Tool Bar updates on release of the icon and the Scan Preset module will display the list of Property Editors for that scan icon. The Flash Camera and the normal Camera icons in the list indicate the preset for the SNAPSHOT and PHOTO functions. These can be moved in the same way as the two scan icons, but these are dedicated to capturing images at selected scan conditions, where as the **Fast** or **Slow** icons are for scan speeds only. The DEFAULT button restores the default list and icon positions.

FIGURE 4-14 SCANNING PREFERENCES



Scan Preset:

Select from the main dropdown the scan (displayed at the top) and then change details in the property editor lists below. Property editor details update to the current condition in their top box. If Details are not relevant to the scan then they show grayed out, and cannot be edited.

Scan Operators

The Fast icon = Fast Scan in the Scan Preset dropdown list.

The Slow icon = Slow Scan in the Scan Preset dropdown list.

The Flash Camera = Snapshot in the Scan Preset dropdown list.

The normal Camera = Photo in the Scan Preset dropdown list.

User Preset = Can be chosen by the user from the dropdown list.

Each of these scan operators has it's own list of property editors below the main dropdown top box so that changes can be made.

Property Editors:

- Dwell Time - The full range of dwell times indicated in the Scan Selection module. Editable.
- Resolution - The range of resolutions indicated on the Tool Bar. Non-Editable.
- Line Time - The full range of line times. Non-Editable.
- Frame Time - Indicates frame time as a result of dwell and line time selected. Non-Editable.
- Filter - Displays the choice of Average, Integrate and Live. All are available to the Fast and Slow Scan conditions, but only Integrate and Live are available to the Snapshot and Photo. Average in these cases is grayed out. Non-Editable.
- No. Of Frames - A list of frames from 1 to 256 in steps. 1, 2, 4, 8, 16, 32, 64, 128, 256. Non-Editable
- Archive Option - Displays a choice of Save, Save As… and None. Selection here determines the result of either Snapshot or Photo, and whether the image is saved with a known label, to a pre-location (Save) or the user is prompted for a name and the location (Save As…). With None selected the image only remains on the screen. Non-Editable.
- File format - A list of useable image formats. Selection should be made prior to capturing the image so that it is stored in the correct format. Non-Editable

APPLY should make the chosen conditions work immediately without updating the old conditions. They will work until the scan is changed or switched off.

OK will update the system with changes made in this dialog till the dialog is opened and the conditions are changed again.

CANCEL returns to the original conditions.

Ion Beam Preferences

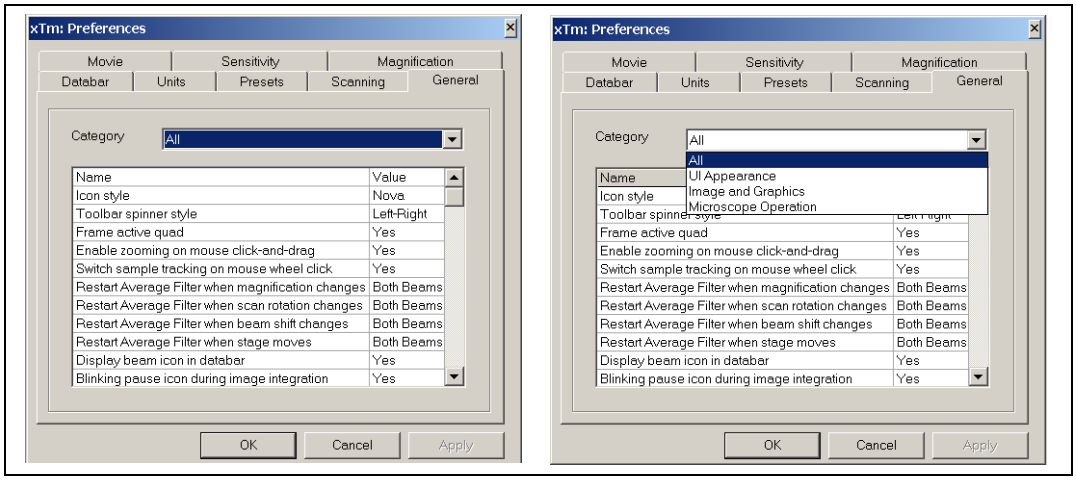
Ion Scanning Preferences are the same as Electron except perhaps some Scan Preset parameters.

The General Tab

allows setting user interface various behaviour. Clicking on any value field causes combo button to appear, which lists available values and allows the user to choose one. In the pull down menu it can be divided into:

- All
- UI appearance only
- Image and Graphics
- Microscope Operation

FIGURE 4-15 GENERAL PREFERENCES



Description and possible Values are:

- **Icon Style**
  Specifies the style of the button icons that the UI shows.
- **Toolbar Spinner Style** (Left-Right / Up-Down)
  Specifies the type of Dwell time spinner in the toolbar.
- **Frame active Quad** (Yes/No)
  Borders the active quad with a blue lining.
- **Enable zooming on mouse click-and-drag** (Yes/No)
  Enabling will make a click-and-drag operation on a SEM or FIB image zoom to the defined area.
- **Switch sample tracking on mouse wheel click** (Yes/No)
  Sample tracking means control of the stage using the mouse wheel; x and y directions in a SEM of RIB quad; z-direction in a CCD quad. Switching this feature off will only move the stage around when the mouse wheel is pressed. Switching this feature on will toggle between sample tracking on and off by simple mouse wheel click.
- **Restart average filter when magnification changes** (both beams)
  Choice of restarting the average filter when the magnification is changed (advised). If not the image can remain with ghost impressions for some time.
- **Restart average filter when scan rotation changes** (both beams)
  Choice of restarting the average filter when the scan rotation is

changed (advised). If not the image can remain with ghost impressions for some time.

- **Restart average filter when beam shift changes** (both beams)
  Choice of restarting the average filter when the beam shift is changed (advised). If not the image can remain with ghost impressions for some time.
- **Restart average filter when stage moves** (both beams)
  Choice of restarting the average filter when the stage is moved (advised). If not the image can remain with ghost impressions for some time.
- **Display beam icon in databar** (Yes/No)
  Display the active beam icon in the databar.
- **Blinking pause icon during image integration** (Yes/No)
  During pause scanning the pause button will blink.
- **Hide Rotation controls when not used** (Yes/No)
  Hide rotation controls if rotation is not to be used in the application.
- **Display Scan Rotation in CCD quads** (Yes/No)
  Choice to display the Scan Rotation logo in the CCD quads.
- **Display Tilt Corrections in CCD quads** (Yes/No)
  Choice to display Tilt Correction logo in the CCD quads.
- **Lower stage when venting the chamber** (Yes/No)
  Lower the stage on venting the specimen chamber or leave the Z axis as is.
- **Change E-magnification when pumping** (set to 100x)
  The magnification of the electron beam will be set to a predefined magnification before pump down.
- **Change I-magnification when pumping** (set to 100x
  The magnification of the ion beam will be set to a predefined magnification before pump down.
- **Switch of CCD automatically** (Yes/No)
  (None/1 minute/10 minutes/30 minutes...)
  The CCD Camera will switch off after timeout.
- **Pause E-Beam quads when switching off HV** (Yes/No)
  When the Electron beam High voltage is switched off scanning will be paused.
- **Pause I-Beam quads when switching off HV** (Yes/No)
  When the Ion beam High voltage is switched off scanning will be paused.
- **Blank E-Beam during long stage moves** (Yes/No)
  Blanking the E-beam during long stage moves to prevent sensitive areas of the stage or sample coming into contact with the E-beam.
- **Blank I-Beam during long stage moves** (Yes/No)
  Blanking the I-beam during long stage moves to prevent sensitive areas of the stage or sample coming into contact with the I-beam
- **Reverse joystick movement** (Yes/No)
  Reverses the direction of movement allocated to the controls of the joystick.
- **Auto switch stage measurement system** (Yes/No)
  Setting this property will automatically switch the stage

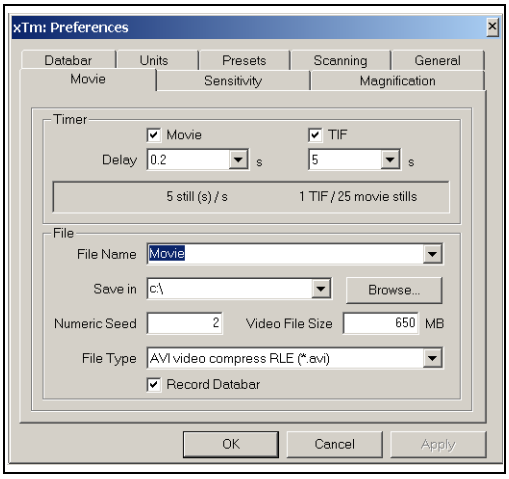
measurement systems off when they are not used, in order to avoid light from "leaking" out of the optical measurement system that may interfere with 3rd party options like EDS detectors.

- **Pause stops immediately (Yes/No)**
  Setting this property will either cause the Pause function to act instantly or wait for the scan to complete.

Movie Tab

The **Movie** tab provides two groups one to choose set-up conditions for timing labelled **Timer**, and the other to set-up save conditions for the resultant movie labelled **File**.

FIGURE 4-16 THE MOVIE TAB DIALOGUE

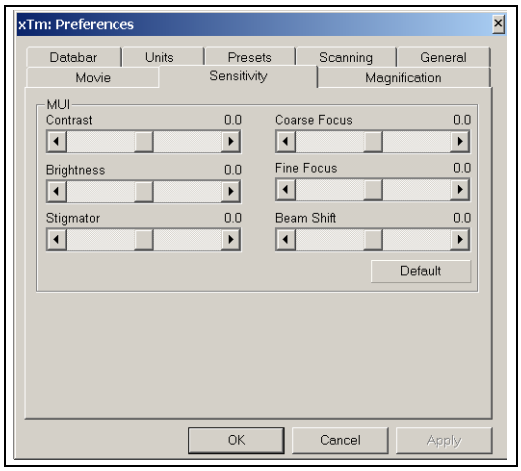


A wider explanation of the **Movie** tab is found in the section ‘Movie (multiple image capture)’.

Sensitivity Tab

The **Sensitivity** tab has the preset sliders for controlling the sensitivity of the Manual User Interface (MUI).

FIGURE 4-17 THE SENSITIVITY TAB DIALOGUE



All controls of the MUI are represented here except Magnification.

The Tool Bar

The **Tool Bar**, displayed below the Menu bar and lets you select system functions by their icons.

FIGURE 4-18 THE TOOL BAR

Rest the cursor on the icon for two seconds without clicking on it to see its highlighted caption (Tool-tips). Tool-tips will display the use of the tool.

Whenever you select a function the corresponding icon is highlighted. Icons that activate an automated procedure are not highlighted.

The tool bar can be different in content or arrangement depending on the system or user preferences.

Beams

This section of the Tool bar contains the Beams functions. These are Electron Beam, Ion Beam and Light Beam. Only one is active at any time, but can be operated independently for each Quad image area. When the Light Beam is active all the remainder of the Tool Bar is inactive.

Column Setting

Magnification/kV/Beam Current/Lens Alignment

These dropdown list boxes can be active for either Electron or Ion beam depending on the beam switched. The value ranges are different for either beam. Clicking the text box allows the list to open for selection of the Magnification, kV or Beam Current. Clicking on the value required will set it in the top window of the dropdown box and at the same time change the column condition to that value. Go to Preferences / PRESETS tab to change values in any of the lists.

Lens Alignment

Toggles lens alignment mode for the objective fine alignment. This is dedicated to the electron column. The scanning condition changes to a fast scan, and the lens modulator turns on, a green target cross appears in the center of all SEM image Quads. Pressing and holding the left mouse button activates a quad arrow ended cursor, and dragging the mouse aligns the beam with respect to the objective lens.

Additional Scan Functions

This section of the Tool bar contains functions such as a **Videoscope** for correcting contrast and brightness, and a **Reduced Area** for specific focus and astigmatism correction. Clicking any of these items will change the image display to suit the function.

Lens and Scan Functions

Z to FWD

The Z to FWD button has 4 conditions:

Greyed icon: the function is disabled because either the stage has not been homed or the HV is switched off (so there is no SEM image), or the Ion Beam is selected.

Red question mark: the function is enabled and the link between Z and FWD is unknown. Use the function as soon as possible, after properly focusing the image.

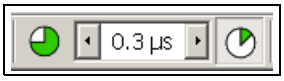
Red circle: Z is roughly linked to FWD, but it needs correction. The function is enabled. It happens e.g. after: changing the specimen, focusing and linking Z to FWD at a long Working Distance and then moving the stage to a short WD. Focus image carefully at a WD around 5 mm and use this function again.

Green double-ended arrow: Z is properly linked to FWD. Now it should be safe to change the Working Distance by setting a Z coordinate in the Stage module. The function is still enabled to allow further corrections of the Z-coordinate.

Auto Functions

This section of the Tool bar contains functions such as **Auto contrast and Brightness** and **Auto focus.** Clicking either of these items will start a procedure of automatic correction.

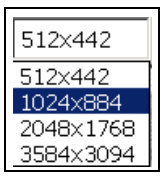
Scan Speeds



This section of the Tool bar contains a number of functions to provide slow or fast scanning capabilities at the click of the tool icon. The left Slow icon is the predefined slowscan and the right Fast icon is the predefined fastscan that has been setup via the Preferences dialog labelled... Scanning. These can be selected for direct access to the preset value.

The center spin-wheel is for changing to the next preset scan speed position in the list. **Down Arrow** is for increasing the scan speed and the **Up Arrow** is for decreasing the scan speed. When either the two presets are active or chosen the respective icon is highlighted. Clicking any of these items to operate will invoke a change to the scan speed.

Pixel Resolution Per Beam



This section of the Tool bar displays a dropdown list box that contains the Pixel Resolutions possible for viewing or recording an image. Clicking on the arrow to the right will drop the list so that all resolutions can be seen. Clicking further on one of these resolutions will invoke the Quad or Full Screen to update to that resolution.

Image capture with Snapshot

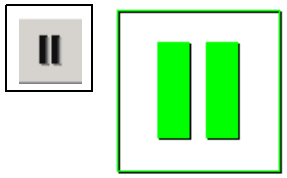
The **Snapshot** icon button is represented as a camera with a fast time disc on the Tool Bar. When an image is required at any time one can click on Snapshot and a single scan (preset scan setting) will be activated which pauses at the end of the frame. The result can be automatically saved on the harddrive to a predetermined file location using the next available label/number if set in the **Scan Preferences**.

Snapshot can also be activated from the **Scan** menu.

Image Capture with Photo

Selecting the **Photo** label in the **Scan** menu will allow a preset high quality, high resolution image to be taken of the milled area. This function also relies on preset conditions in the **Scan Preferences**.

Pause



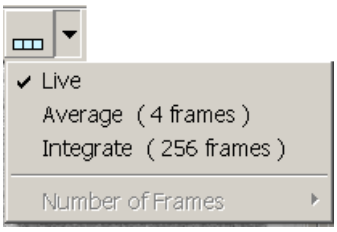
The Icon button is 2 vertical bars. Clicking once on Pause will stop the scan immediately without continuing to the end of frame. The 2 vertical bars stay black with the button pressed in. When the scan has stopped the button remains pressed in.

When Pause is pressed two vertical green bars surrounded by a green box appear, in the top left corner, of the full screen or quad that is focused on at the time.

To release Pause click once on the pressed in button, the button will pop out and the bars remain black.

Filtering

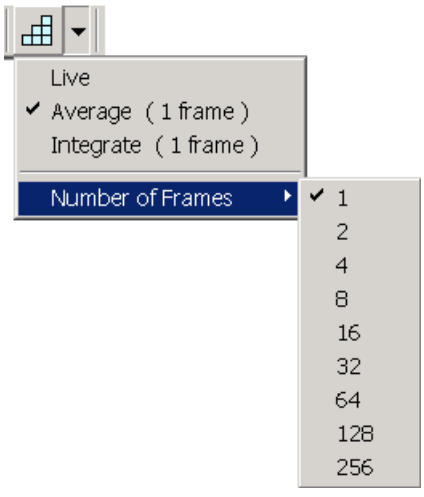
This section contains 4 items related by conditions of filtering of the raw scanned image. The Icon button when clicked on passes from one function to the next, and so on. When the down arrow is clicked on the selection dialog opens so that the **Average** and **Integrate** functions can be loaded with frame values.



The functions are as follows:

- The first 3 bricks(frames) represent **Live** imaging as one frame follows the other. Therefore there is no filtering and this is the raw scanned image.
- The second ascending 6 bricks(frames) denote an improving image with successive **Average** of 2 or more frames. This process will continue until stopped by change of scanning condition or by freezing the result.
- The third stairway 6 bricks (frames) shows an increasing number of frames that **Integrate** to an end value. This process will continue until the predefined number of frames is reached, and then stop and freeze automatically.

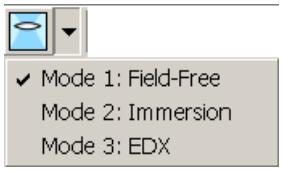
If you select 1 of these 3 options from a frozen (paused) image state, the imaging will start automatically without the need to unpause it, using the selected filter mode.



Number of Frames

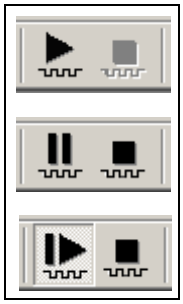
The dropdown list box contains the type of filter and the number of frames for each value of **Average** or **Integrate**. Live is always one frame. Clicking on the arrow in the NUMBER OF FRAMES section to the right will drop the list so that all filter values can be seen. Clicking further on one of these values will invoke the display to update to that condition. Frame values for average and Integrate are independent of each other, and of scan speeds, so values can be preset for particular scan, beam and Quad conditions. A filter should be set per quad, per beam. So live and filtered images of a beam can be seen at the same time and if the a new beam is chosen it reverts to the preferred setting for that beam.

Modes 1, 2 or 3



The Mode icon displays one of three modes, either Mode 1 (Field Free), Mode 2 (Immersion) or Mode 3 for EDX. Mode 1 is a Field Free mode setting of the lenses for the column to allow low magnification searching of the samples or sample area. Mode 1 is also for x-ray analysis or magnetic samples, selection can be made in the Preferences dialog Tab labelled BEAM. Mode 2 (Immersion) is a higher resolution mode for the viewing of the sample at higher magnification. Mode 3 is used for EDX operation where the lens is used as the magnetic trap for EDX analysis.

Patterning



A 4 in 1 Patterning Icon button is used to Start/Pause/Resume Patterning. When the **Start**/Stop/Pause/Resume Patterning button is active it changes to the Start symbol in black.

When the Start/**Stop**/Pause/Resume Patterning button is active it changes to the Stop symbol in black.

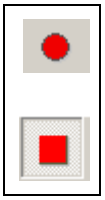
When the Start/**Pause**/Resume Patterning button is active it changes to the Pause symbol in black.

When the Start/Pause/**Resume** Patterning button is active it changes to the Resume symbol in black and depressed.

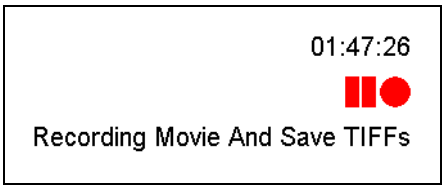
The Reset Icon button is gray when non-active and black when active.

NOTE: While E-beam Snapshot is running, pressing Stop will pause the pattern so that it is in Resume mode and therefore the pattern can be continued when Snapshot has finish.

Record Movie



The RED dot is the start command button that starts the recording of three videos, one for each of the three image quads at the same moment. If a quad is paused when starting the video, only the first image with a time stamp is stored. When the red dot, representing 'Start', is pressed it turns to a RED box, representing 'Stop'.



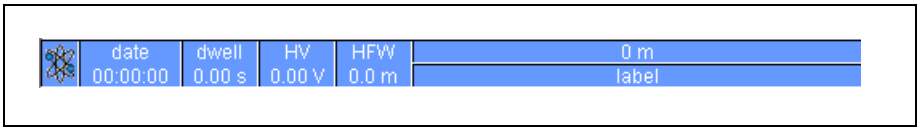
A RED dot and timer appears on each quad.The timer starts and updates as the recording proceeds to the timing set in the Movie Preferences Tab. The Recordings will automatically stop at the time entered in the Movie Preferences Tab, otherwise when pressed, the RED square then stops the recording of the video of all three quads and closes the files. The two red bars indicate that the record is running but the data from this quad is will not be stored automatically.

The Data Bar

Data Bar

The **Data Bar** displays Instrument, Image and labelling information, presented by preset choice via the Preferences dialog tabbed Databa**r**. This can be a combination of, for instance, kV, Detector, X and Y coordinates etc. They can be placed in any order and will expand or contract to fit. There is also a micron bar above the user's label area.

FIGURE 4-19 THE DATA BAR



Data Bar Colour coding

The following table defines the status conditions of the DataBar.:

TABLE 4-3 DATABAR STATUS

Quad Status	Scan Condition	Background Colour	Text Colour
Selected	Live	Blue	White Text
Not Selected	Live	Gray	White Text
Selected	Pause	Blue	White Text
Not Selected	Pause	Gray	White Text
Selected	Patterning	Light Green	White Text
Not Selected	Patterning	Dark Green	White Text

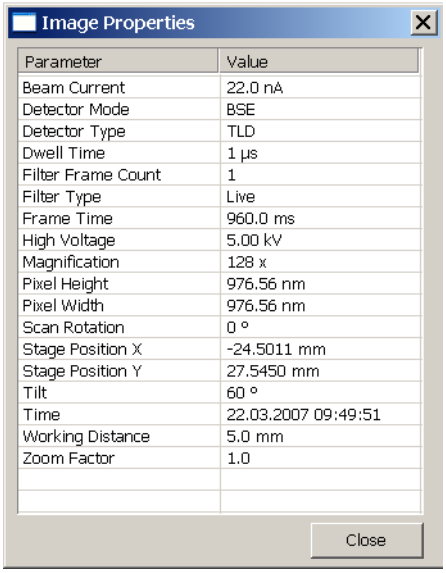
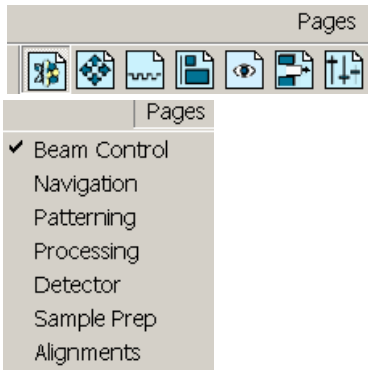


Image Properties

Clicking once in the databar area of a quad (not the label area) will result in a pop-up dialog showing full properties relating to the image in the quad. The dialog can be left open and by clicking in another quad databar it will change property data accordingly. The dialog can be closed by clicking on the Close button.

Pages and Modules



The control icons above the page area on the right side of the screen are organized into **Pages**. Several pages are divided into smaller modules that hold specific functions. The most frequently used controls appear as modules on more than one page. Select the page required by clicking on the Icon. Allowing the cursor to dwell for a few seconds over the icon will display a Tool-Tip giving the name for the page. The page can also be selected from the drop down menu below the word **Pages** on the **Menu Bar**.

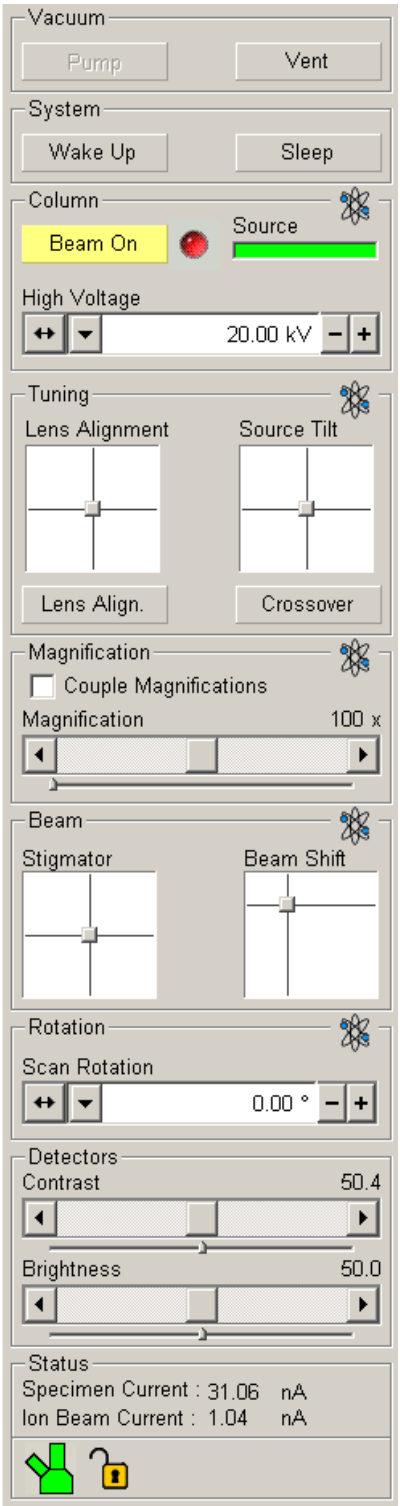
TABLE 4-4 PAGES

Icon Buttons	Page	Modules
	Beam Control	Vacuum System Column Tuning Magnification Beam Rotation Detectors Status
	Navigation	Stage Retractable STEM Load Lock Detectors Status
	Patterning	Pattern Progress Omniprobe Gas Injection End Point Monitor Status
	Processing	Measurement / Annotation Digital Zoom Enhanced Image Detectors Status
	Detector	Detector Settings Charge Neutralizer

TABLE 4-4 PAGES

Icon Buttons	Page	Modules
	Sample Prep	Pattern Progress Omniprobe Gas Injection Scan Rotation Stage
	Alignments	Alignment Instructions Steps Status

Beam Control Page



The **Beam Control Page** is divided into modules:

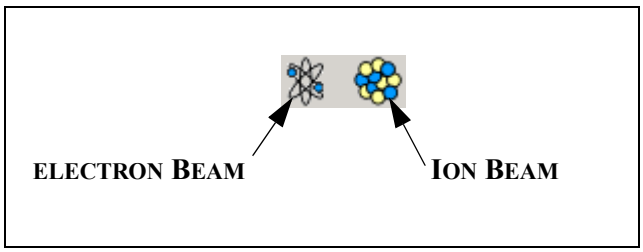
- **Vacuum**
- **System**
- **Column**
- **Tuning**
- **Magnification**
- **Beam**
- **Rotation**
- **Detectors**
- **Status**

The Beam Control Page is a User level page. It contains the essential components such as the vacuum control to pump and vent the system and the beam and column modules to control either the Electron or the Ion columns.

Column Type

The column control type will be displayed by the icon logo representing either the Electron column or the Ion column. These can be switched for operating in individual Quads from the two Icon buttons on the Tool Bar.

FIGURE 4-20 COLUMN ICON LOGOS



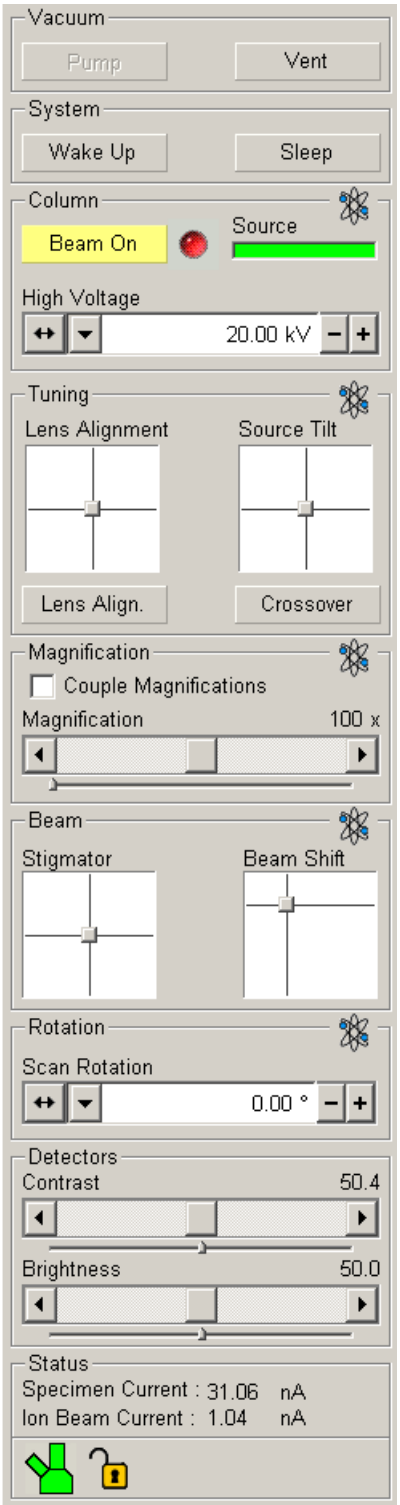
On all pages the Status module is found at the base of the page.

Vacuum

The Vacuum module is used during specimen exchange or to change the instrument status in the and around the final lens pole.

Pump

The PUMP button starts the pumpdown procedure for the specimen chamber. For Turbomolecular Pump (TMP) systems evacuating the specimen chamber is immediately through this pump. When the chamber is evacuated, the system allows High Voltage to be switched on when the pressure in the chamber and the column are ready for operation.



Vent

Pressing the VENT button initiates the following sequences for the respective columns and GIS system:

- Electron column: Switches High Voltage off and closes the Column Isolation Valve (CIV).
- Ion column: Beam is blanked and closes the Column Isolation Valve (CIV).
- The GISs close and retract, the GIS heaters are turned off.

System

The System module contains the WAKE UP and the SLEEP buttons.

Wake Up

Both beams can be started by clicking on the WAKE UP button. The High voltages and Ion Source (including heating if necessary) are started with WAKE UP.

Sleep

Both beams can be stopped by clicking on the SLEEP button. The High voltages and Ion Source are stopped with SLEEP.

Column

The Column module contains the same controls for the Electron beam or the Ion beam. These are:

Beam On

Pressing the BEAM ON button initiates the following sequences for the respective columns:

- Electron column: Switches High Voltage On/off and opens/closes the Column Isolation Valve (CIV).
- Ion column: Opens/closes the CIV, selects the last used aperture, selects the highest High Voltage (30 kV) and turns the ion source on, if it was not running.

When activated, the BEAM ON button changes from gray to yellow. If you click the BEAM ON button when it is yellow, the button changes back to gray. The Icon logo for the beam in active operation is displayed at the right side of the module.

High Voltage

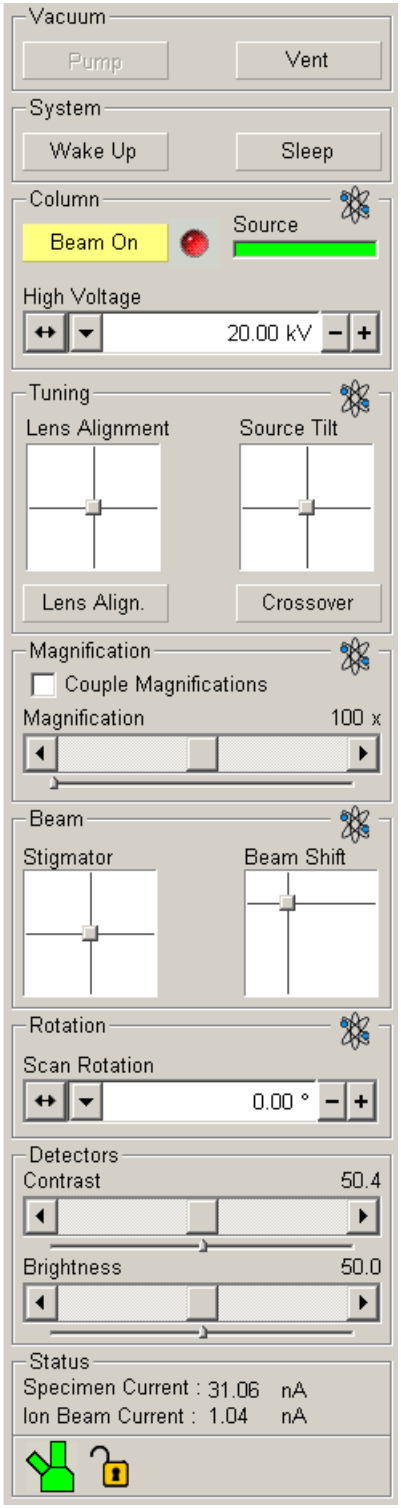
The High voltage slider can be adjusted to give the required voltage. Both columns can be adjusted in this way.

The Electron column ranges from 200V to 30kV.

The Ion column ranges from 2kV to 30kV

Source

This is a progress indicator for the Electron and Ion source startup from SLEEP.



Tuning

The functions in this module are dedicated to the Electron beam only.

Lens Alignment

The LENS ALIGNMENT X-Y control moves the beam relative to the Final Aperture to remove shift during focus. This may have to be used during daily operation and can be easily corrected in conjuction with the Lens Modulator.

Lens Align

The LENS ALIGN button switches on an automatic modulation of the focus. From the actual focus setting, it generates a focus range with a minimum and a maximum focus. The range is dependent on the applied magnification. This is only effective with the E-Beam.

Click with the left mouse button on the LENS ALIGNMENT area. The four-way arrow cursor is shown on the full screen. Move the cursor left/right and up/down, to control the lens align X and Y. The actual position of lens align is always shown by the position of the crosshair in the X-Y control.

Use this function at a fast scanning rate to view the immediate response of the system with the modulator on. If the system is well aligned, the rotation center is at the center of the image (at low magnification, 200X). At higher magnification (>20,000X), the image does not move from the rotation center during modulation of the focus or during normal focusing actions. If out of center the X,Y controls of the Lens Align are use to center the rotating modulation.

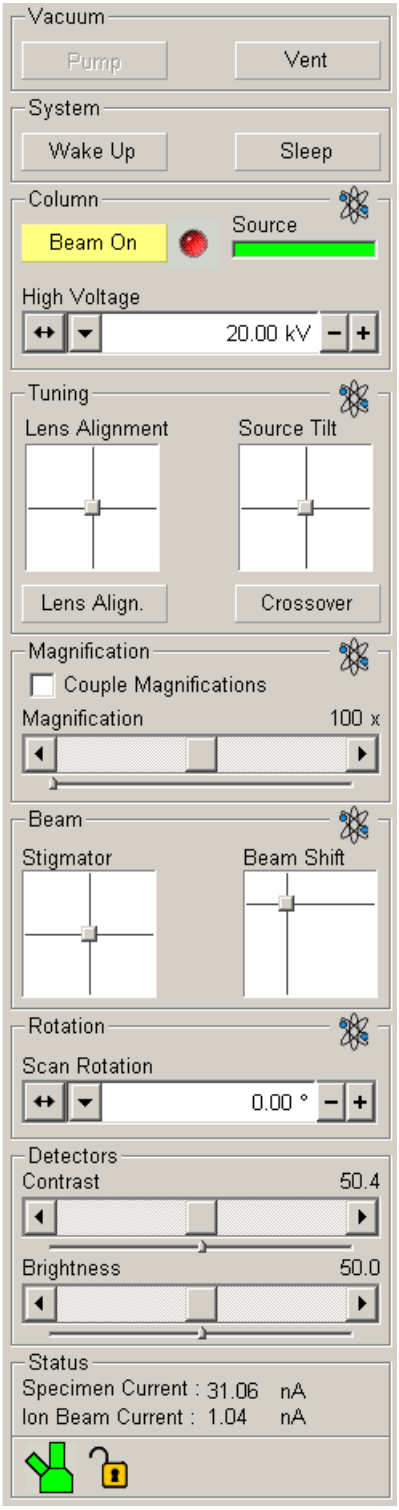
Clicking on the right mouse button while over the 2D box area will show a small dialog to ‘Zero’ the control or to select it’s operating function, linear or logarithmic. This is the same for all 2D controls on this page.

Source Tilt

The SOURCE TILT X-Y control indicates the actual setting of the electronic gun tilt with respect to its extreme settings. Source Tilt changes the effective angle of illumination of the beam coming from the source area of the electron column. Use it to manually center the illumination (maximize beam brightness) on the Beam Defining Aperture (BDA) in the crossover mode. This adjuster is a temporary override of the setting predefined in the alignment procedure.

Click with the left mouse button on the SOURCE TILT area. The four-way arrow cursor is shown on the full screen. Move the cursor left/right and up/down, to control the Source Tilt X and Y. The actual position of Source Tilt is always shown by the position of the crosshair in the X-Y control.

The Electron beam Icon logo is displayed at the right side of the module.



Crossover

The CROSSOVER button is available only when the System and Column modules are in operation.

Crossover allows imaging of the source and is useful during the alignment procedure. Also, if the column aperture is severely misaligned, the image of the crossover can be very helpful. The crossover is visible in a slow scanning mode, and as a help, the center of the screen is marked with a cross. The crossover should be in close vicinity to the cross. It can be set to the correct position by manipulation of the aperture. If, in this condition, the crossover mode is switched off, an image will appear on the screen.

Magnification

The Magnification module gives access to coupling the magnification of both beams. The magnification is set with the slider and then locked by ticking the box labelled COUPLE MAGNIFICATIONS. The Icon logo for the beam in active operation is displayed at the right side of the module.

Beam

The Beam module displays controls that are used by both Electron and Ion beams.

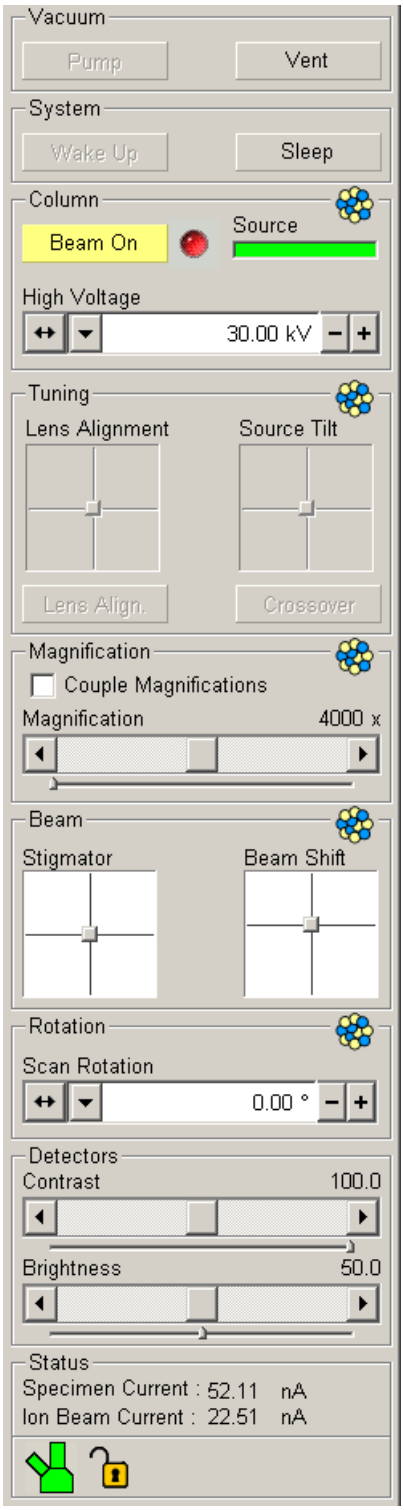
Stigmator

The STIGMATOR is a two-dimensional X-Y control that allows you to change the stigmator setting. The crosshair indicates the actual setting of the stigmator. Click the left mouse button in the X-Y control. The hand-cursor appears onscreen. Move the mouse left to right to modify the X-stigmator. Move the mouse up and down to change the Y-stigmator. Note that the stigmator range is coupled with the magnification. When the stigmator has been adjusted correctly, release the left mouse button. The position of the cross in the reserved adjustment area updates. You can also use the SHIFT + right mouse button for stigmation.

Beam Shift

The BEAM SHIFT is a two-dimensional X-Y control that allows you to change the Beam Shift setting. The crosshair indicates the actual setting of the Beam Shift. Click the left mouse button in the X-Y control. The hand-cursor appears onscreen. Move the mouse left to right to modify the X-direction. Move the mouse up and down to change the Y-direction.

The Icon logo for the beam in active operation is displayed at the right side of the module.



Rotation

The SCAN ROTATION adjuster is a Preset/continuous control adjuster to give access to set rotation angles as well as a variable angle values.

Detectors

Contrast

Use this adjuster to control the contrast of the active detector.

Brightness

Use this adjuster to control the brightness of the active detector.

The end arrows give a finer control. The mini sliders below the main sliders give a linear control, while the large slider gives logaritmic control.

Status

The Status area is used for the feedback of parameter conditions as the system is being operated. These parameters may change due to the application being monitored at any time. It is found at the base of all pages.

Navigation Page

Overview

The **Navigation Page** is divided into modules:

- **Stage**
- **Detectors**
- **Status**

The Navigation Page is a User level page. It contains the essential components for navigation.

Stage

The Stage module allows control of the stage for positioning, location store/recall, and mapping of coordinates. There are two tabs labelled MAP and COORDINATES for visual and numerical movement use.

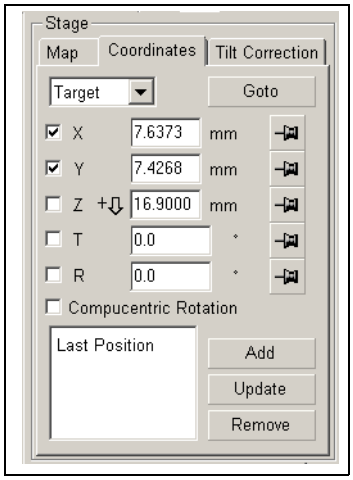
Map Tab

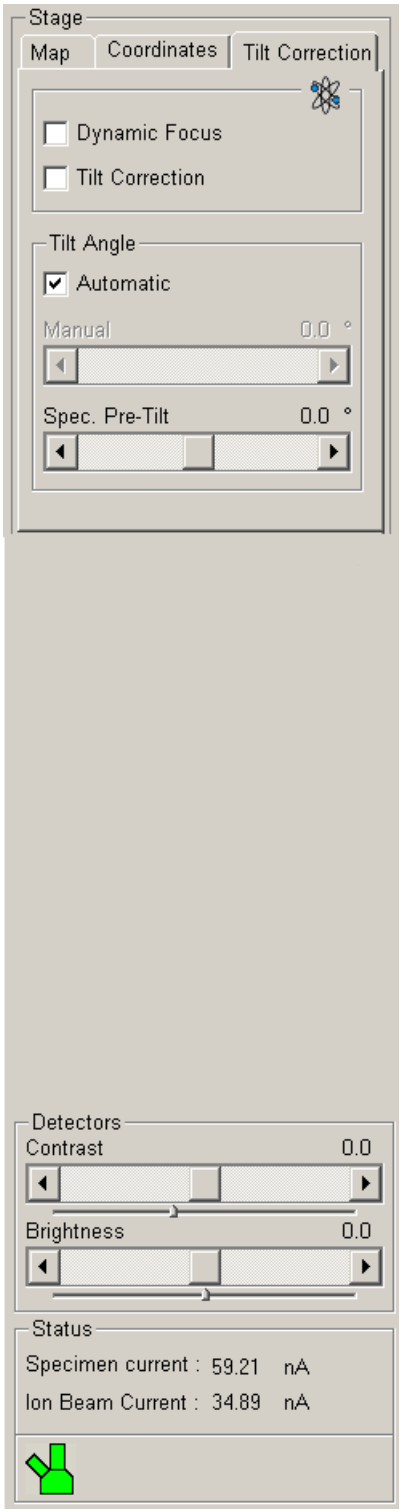
The MAP tab displays the location of positions on the stage in a visual map form and in a list for selection. Clicking within the stage map area drives the stage to the position selected. Positions can be stored in a file and contribute to a map of locations that can be reintroduced at a later date for re-investigation of the same sample.

Coordinates Tab

The COORDINATES tab displays numerical information about a particular position when selected from the LOCATION list. Position values can be entered to drive the stage to a set position and a tick indicator occurs in the box to the left of the (to be moved) parameter to indicate Target position. Coordinates can be Actual, Target or Relative. Any or all movements can be locked. The stage lock for any of the axes is graphically displayed in the Status area as an open or closed lock.

FIGURE 4-21 TABBED COORDINATES DISPLAY





Tilt Correction Tab

The Tilt Correction Tab contains correction features to the tilted image. When these are ticked in the boxes they become active.

Dynamic Focus

Click in the checkbox to switch DYNAMIC FOCUS on or off. When it is on, the scan slowly proceeds from top to bottom and the focus point is automatically changed according to the positive tilt of the specimen. The focus should be adjusted by the operator to be sharp in the middle of the image - then the dynamic focus will ensure that the image is sharp all the way from top to bottom.

DYNAMIC FOCUS can only be used with scan rotation at zero. You must enter SPECIMEN PRE-TILT for the calculations to be accurate.

DYNAMIC FOCUS can be used for a strongly tilted specimen (either by the specimen surface itself or by stage tilt), when the depth of focus is not sufficient. It results in an image with overall sharpness. It is usually used usually at low magnification and it works only in mode 1.

Tilt Correction

Because the image is a two-dimensional representation of a three-dimensional object, certain projection distortions occur. The more highly tilted the specimen is, the more foreshortened its image will be. Applying a tilt correction will compensate for foreshortening in one direction on a flat specimen at a known tilt angle (80° range) and when the tilt axis is parallel to the scan line.

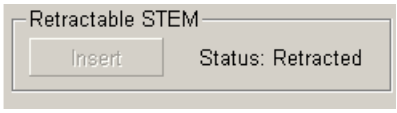
TILT CORRECTION can only be used with scan rotation at zero. You must enter SPECIMEN PRE-TILT for the calculations to be accurate. For example, a square grid image will appear rectangular when you tilt the specimen. Applying TILT CORRECTION will correct the aspect ratio and restore the square appearance.

Tilt Angle

Use automatic if the correction angle to be used is the same as the stage tilt angle (including Specimen pre-tilt, see below). Use Manual to manually enter the angle for which the dynamic focus and tilt correction compensate for.

Specimen Pre-tilt

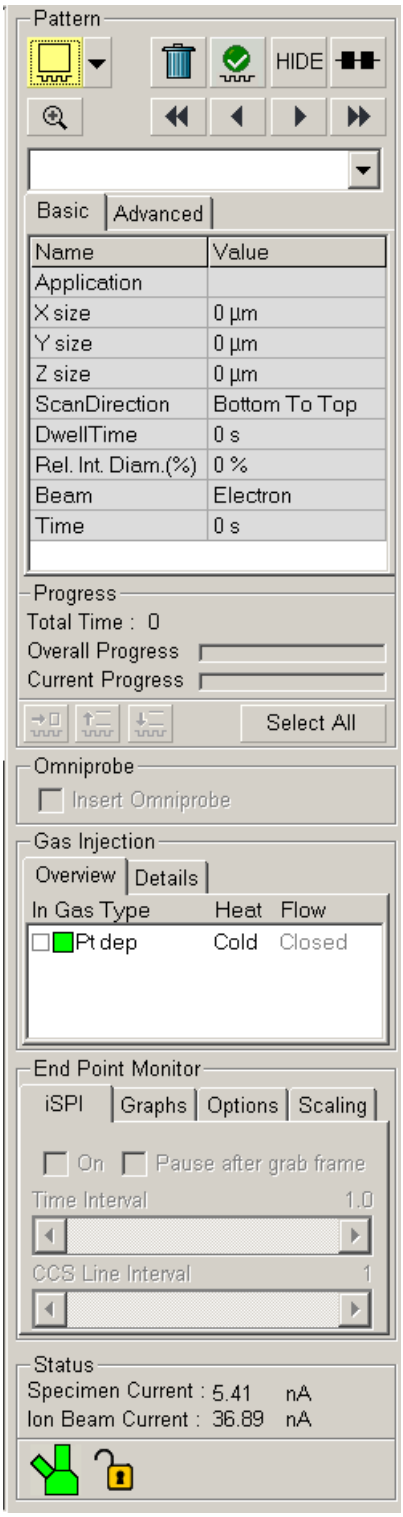
Use this adjuster only in conjunction with DYNAMIC FOCUS and, or TILT CORRECTION. Enter the specimen tilt angle on the slider and then tick the necessary checkbox. If Tilt mode is selected to be Manual (see above), the slider value now indicates the absolute angle that should be used for the compensations (regardless of the actual stage tilt angle, or specimen pretilt).



Retractable STEM (Option)

The STEM detector is permanently mounted in the chamber and is retractable when not in use. This is controlled in the Stage control page by clicking on the Insert/Retract button.

Patterning Page



The **Patterning Page** is divided into modules:

- **Pattern**
- **Progress**
- **Omniprobe**
- **Gas Injection**
- **End Point Monitor**
- **Status**

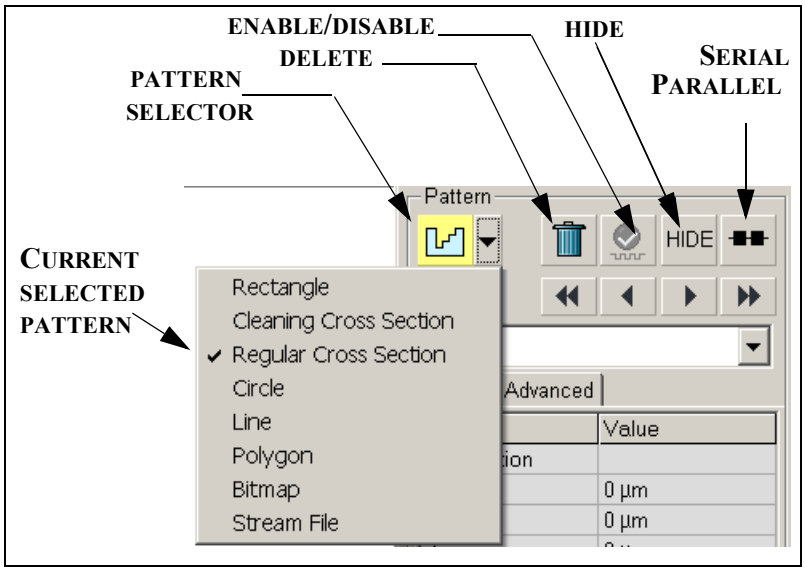
The Patterning Page is a User level page. It contains the essential components to perform Patterning.

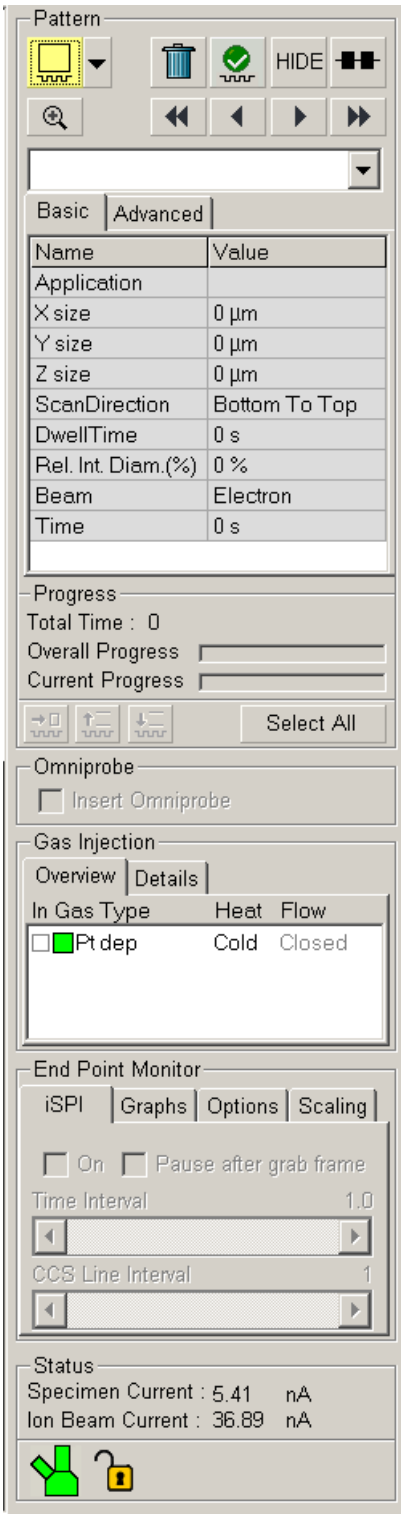
Pattern

Pattern shapes can be selected and drawn, their data entered and displayed with this module.

A shape can be selected by clicking on the PATTERN SELECTOR and the details filled in the pattern details list. The pattern is allocated a number relative to that shape and is displayed in the PATTERN LIST. When the PATTERN SELECTOR displays a yellow shape, that shape can be drawn in the selected quad with the small cross cursor. The pattern CONTROL CURSOR allows for selection between the drawn patterns in a quad.

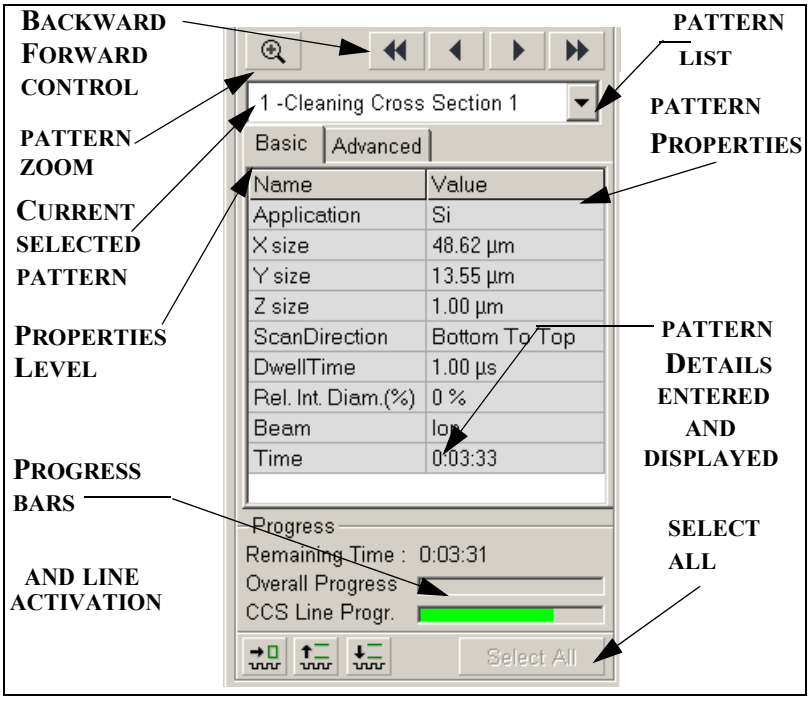
FIGURE 4-22 PATTERN SELECTION CONTROLS





The pattern displayed via the PATTERN SELECTOR on the Patterning Page responds to the pattern highlighted in the working quad.

FIGURE 4-23 PATTERN PROPERTIES CONTROL



Progress

This module displays the overall and current progress (over time) of the active Patterning.

Pattern and Line Activation

The three buttons below the progress section are fast activation buttons for:

- Next Pattern - activated when more than one pattern is present.
- Next Line - activated when Cleaning Cross Section is operative.
- Previous Line - activated when Cleaning Cross Section is operative.

The same functions can be found in the dropdown Patterning Menu.

Omniprobe

The Omniprobe micro manipulator allows you to extract a TEM sample in situ. By selecting or deselecting the checkbox the Omniprobe needle can be inserted or retracted.

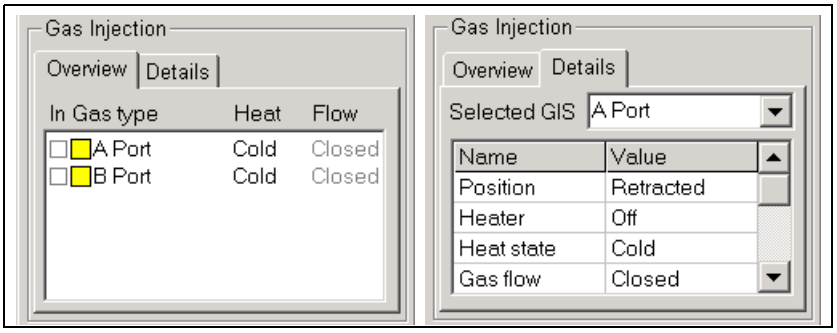
Gas Injection

The Gas Injection modules provides the capability to select the type of gas deposition or etch.

Overview Tab

On the OVERVIEW tab the checkbox to the left of the Gas Injector, labelled IN, is the toggle for in or out activation of the injector. The gas type is the gas assignment to the port. The HEAT status is a toggle between cold or hot, and the FLOW status is a toggle between closed or open.

FIGURE 4-24 GAS INJECTOR OVERVIEW / DETAILS

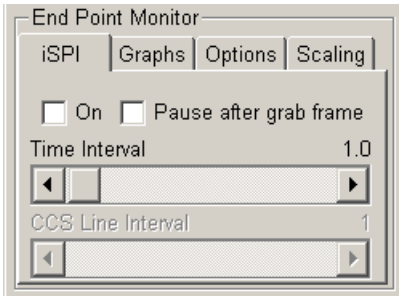


Details Tab

Clicking on the DETAIL tab will display the characteristics of the active Gas Injector. The characteristics can be changed by entering the details to configure the injector.

End Point Monitor (EPM)

The End Point Monitor gives visual feedback to the progress of a milling process. This device can be activated to start when patterning starts, stop when patterning is paused and restart when patterning is continued.



iSPI mode

Choose the required rate for the iSPI image

Unpause Electron imaging in Quad 1

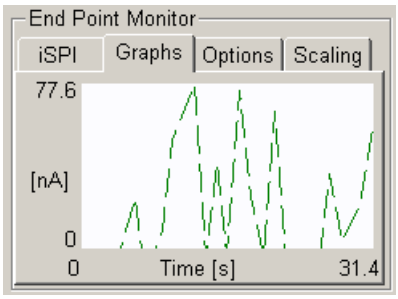
It is possible to unpause other Electron beam quads with different detectors (e.g. ETD and STEM). Simultaneous images are grabbed in such a case.

Using iSPI mode with a Cleaning cross-section pattern, it is possible to take an Electron beam image every 'x' number of slices. This interval is selected via the 'CCS Line Interval'.

Using iSPI mode with other patterns, it is possible to take and Electron beam image after 'x' seconds. This interval is selected via the 'time interval' slider

The frequency Electron beam images can be selected via the sliders, while the patterning progress can be paused after Electron beam imaging, to allow for detailed inspection of the image, before progressing.

Graphs



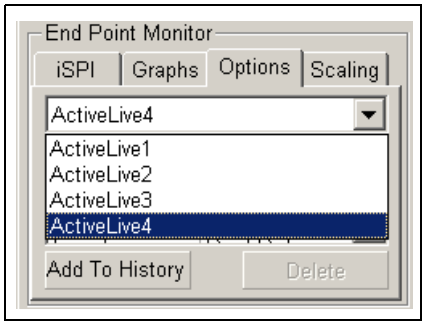
The GRAPHS tab illustrates in live time the cutting depth progress monitored by specimen current. This means the milling progress can be observed as a colored graphical display, showing the specimen current profile over the progressively milled area.

Options

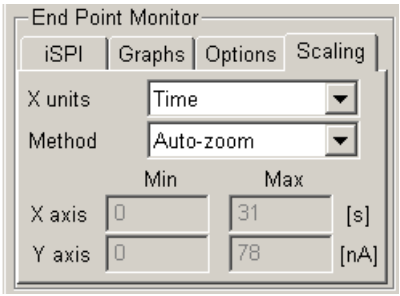
The OPTIONS tab allows selection of any number of milling processes being monitored to be graphically displayed. The ACTIVELIVE# selected will be active until changed.

ACTIVELIVE# = Quad# The IC pattern started in Quad 1, ACTIVELIVE1 appears if set to display.

FIGURE 4-25 EPM Options

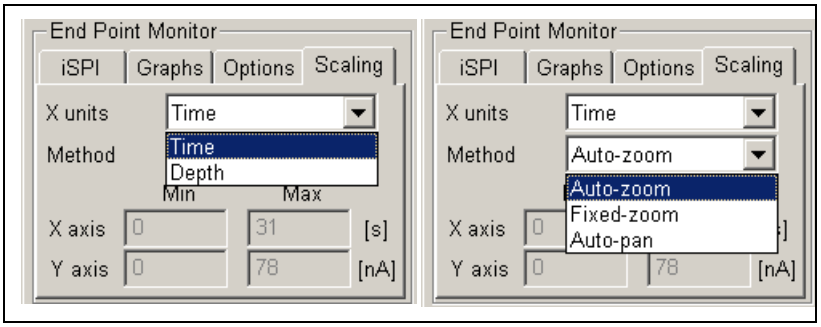


Scaling



The SCALING tab can be set via X UNITS to Time or Depth. This will correspond to how the progress is observed.

FIGURE 4-26 EPM SCALING



The operating METHOD can be selected from Auto-zoom, Fixed-zoom or Auto-pan.

Processing Page

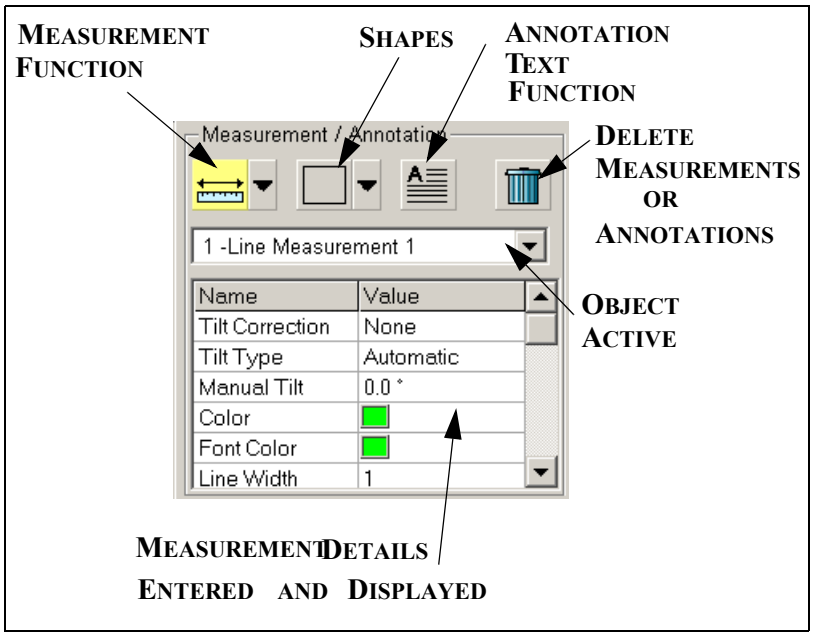
The **Processing Page** is divided into modules:

- **Measurement / Annotation**
- **Digital Zoom**
- **Enhanced Image**
- **Detectors**
- **Status**

Measurement / Annotation

This module combines the functions for measuring and making annotations in all images. A measurement tool, an annotation shape or a text label can be selected from the first three icons on top of the module, and then drawn in a image Quad. All objects are sequentially indexed and displayed in list box below the icons.

FIGURE 4-27 MEASUREMENT FUNCTION ACTIVE



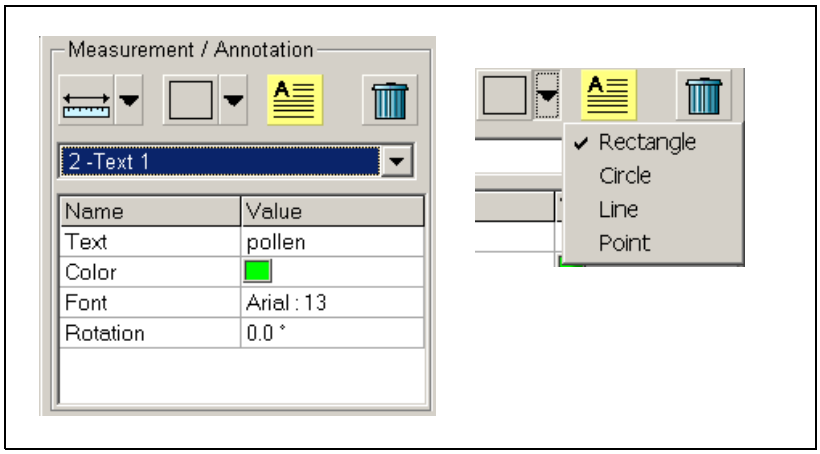
Measurement

Measurement allows the user to draw various shapes on the Full screen or the active Quad for purposes of displaying measurement of linear distances, diameters, angles or areas of the image. Numerical values are updated while drawing and display alongside or within the finished measured item. Selection of individual properties can be made in the property editor, some of these operating dropdown choices, such as Color.

Annotation

Annotations allow the user to draw on the Full screen or the active Quad for purposes of highlighting features by displaying linear distances, circles, areas or text. Selection of individual properties can be made in the property editor, some of these operating dropdown choices, such as Color.

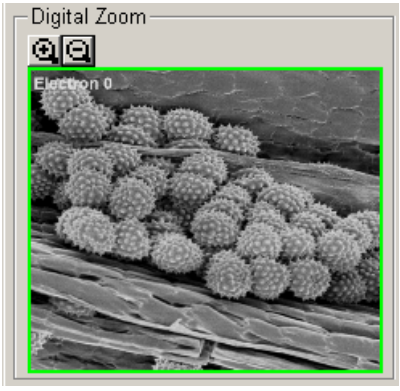
FIGURE 4-28 ANNOTATION FUNCTION ACTIVE



The Measurement / Annotation module icons have the following functions:

- **Select Measurement / Annotation type**. Selects (highlighted) / deselects an measurement / annotation shape.
- **Text**. selects (highlighted) / deselects a text annotation. If no measurement tool nor any shape or text label is selected, the existing objects can be moved, resized or rotated using the mouse.
- **Delete selected objects** (Trash can) the **objects list box** enables to select an existing measurement tool or annotation. Parameters of the selected object are displayed and can be modified in the property editor below.

NOTE: The Measurement tools have their physical dimensions which scale with the image - when changing magnification, the displayed tools change their size accordingly. On the contrary, the Annotation shapes and texts have their sizes fixed relatively to the Quad.

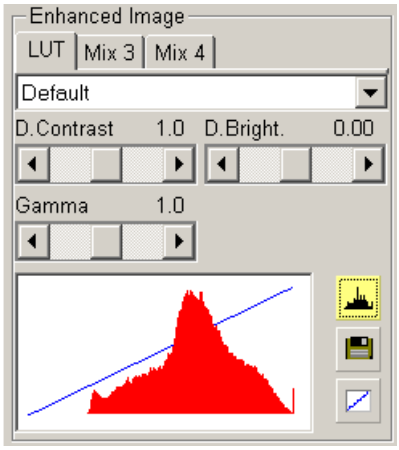


Digital zoom

The function can be used on live images, still images for the electron beam, ion beam as well as the CCD Image. Using this function, it can

- Increase/decrease zoom factor
- Pan zoomed image
- Undo digital zoom or redo digital zoom (whatever is applicable).

The digital zoom factor can be displayed on the data bar. The zoom icon is displayed on the zoomed image.



Enhanced Image

Consists of functions for digital image enhancement and mixing.

The digital processing does not influence the original (raw) image stored in the image memory, and therefore can any time be modified or switched off (undone) completely. The digital image enhancement can be applied to any detector image, including CCD, and also to paused or loaded images. In contrary to Detector Contrast and Brightness functions, the image enhancement functions are applied only the active Quad, independently from other Quads settings.

Lut Tab

Contains tools for monitoring and modifying greylevels distribution (histogram) of a greyscale image. The digital image processing defined in this section is the first one applied to the image (possibly after integration / averaging).

Presets List Box

Enables to select the Digital Contrast / Brightness / Gamma values at once using a pre-defined or custom preset.

Digital Contrast Continuous Adjuster

enables contrast to be set in range from -10 to +10 (negative values lead to an inverse imaging)

Digital Brightness Continuous Adjuster

Enables brightness to be set in range from -2.0 to 2.0

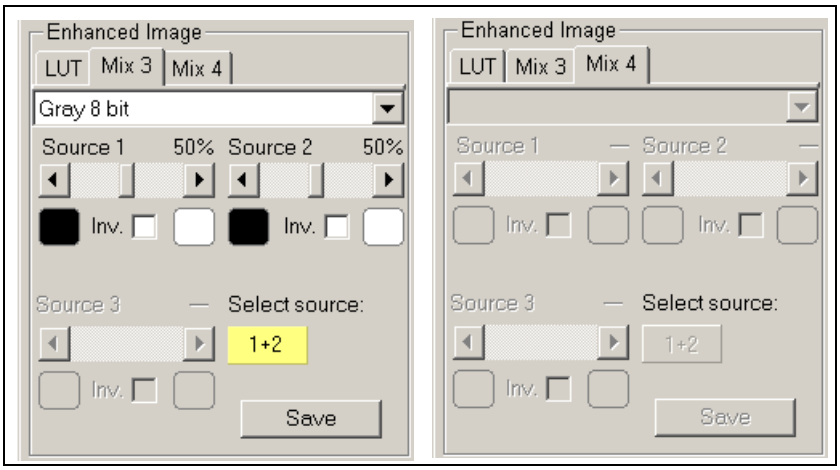
Gamma Continuous Adjuster

corrects image brightness non-linearly in range from -10 to +10

Graph Window - The Histogram Button

Switches on/off the greylevel histogram corresponding to the active Quad image. Left / right side of the histogram corresponds to black / white pixels in the original image, and the height of each red line is proportional to the number of pixels with the corresponding gray value.

FIGURE 4-29 ENHANCED IMAGE MIX FUNCTIONS



Graph Window - Save Button

Saves the current Digital Contrast, Brightness and Gamma settings.

Mix 3 / Mix 4 Tabs

Quad 1 is the top left and Quad 4 is bottom right, with the others running horizontally. All quads can contain live images with Electron, Ion or Optical beam. The Status of the Quad is also defined by the Beam type (displayed by the beam icon) and whether it is paused or not (displayed by the pause icon). Only one image window has focus at any time (recognizable by a light blue data bar instead of a grey one), although the others can have live images.

In Mix detectors mode, Quad 3 can display a mixed image from quad 1 and 2 images and Quad 4 can display a mixed image from quad 1, 2 and 3 images.

Source 1 - 3 Linear Continuous Adjusters

Enables to tune the mixing ratio of Quad 1 - 3 images. The value of each adjuster (0 - 100%) says how big part of the resulting image composes the corresponding source image. Changing one Source value results in automatic change of the other (two) values so that the sum of all Source values is always 100%

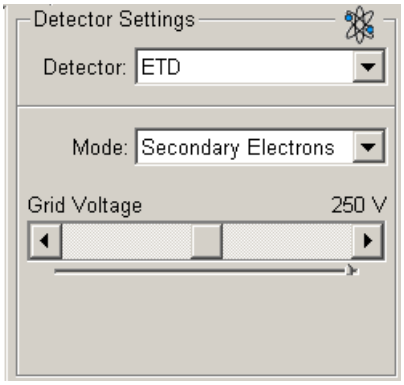
Invert Check Boxes

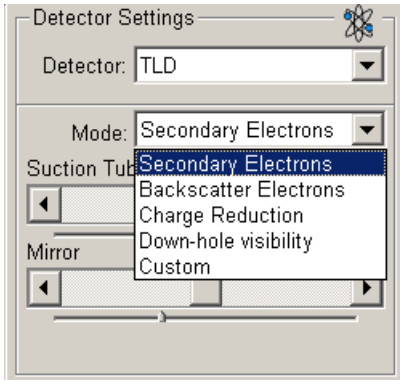
Inverts the corresponding Source image spectra. It has the same effect as exchanging the left and right colours selection.

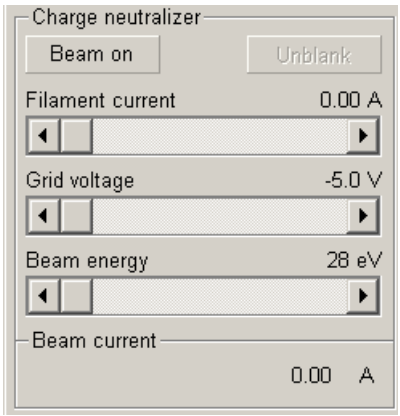
Mix 3 (1 + 2) / Mix 4 (1 + 2) Buttons

are useful for mixing into Mix 3 and Mix 4 respectively. They switches between two mixing modes available in Quad 3 (Quad 1 + Quad 2) or three mixing mode into Quad 4 (Quad 1 + Quad 2 + Quad 3). In Quad 3 (Mix 3), the Source 3 controls are disabled

Detector Page







The **Detector Page** is divided into modules:

- **Detector settings**
- **Charge Neutralizer**

Detector settings

The Detector Page is a User level page. It contains essential components for selecting a detector, change its settings, and also contains an option function for controlling the charge neutralizer.

The selectable detectors for Electron beam and Ion beam operation are listed in the Detector list box. Clicking on the list box arrow will show the available detectors for either the Electron beam or the Ion beam. It also will activate the mode selection for imaging. Depending on the beam mode in operation only the relevant detectors and mode will appear in the list. The default setting for both Electron beam and ion beam is the ETD detector.

Customizing settings

Customizing a detector can be done by selecting from the drop down list in the Detector Setting module on the Detector Page. As soon as the bias is changed, custom mode is auto selected. Selecting another mode, other than custom, causes the bias to snap back to the default for that mode. All the default operating modes are with the selected detector under mode. The customized value will be reset when another detector mode is selected. It is possible to mix 1st and 2nd Quad detector signal in the 3rd Quad by choosing Mix in the Detector menu for Quad 3. It can also be activated by the function of Mix 3 in the Processing page / Enhanced Image module. The active detector in a Quad can also be selected from the Detector menu located on the Menu Bar.

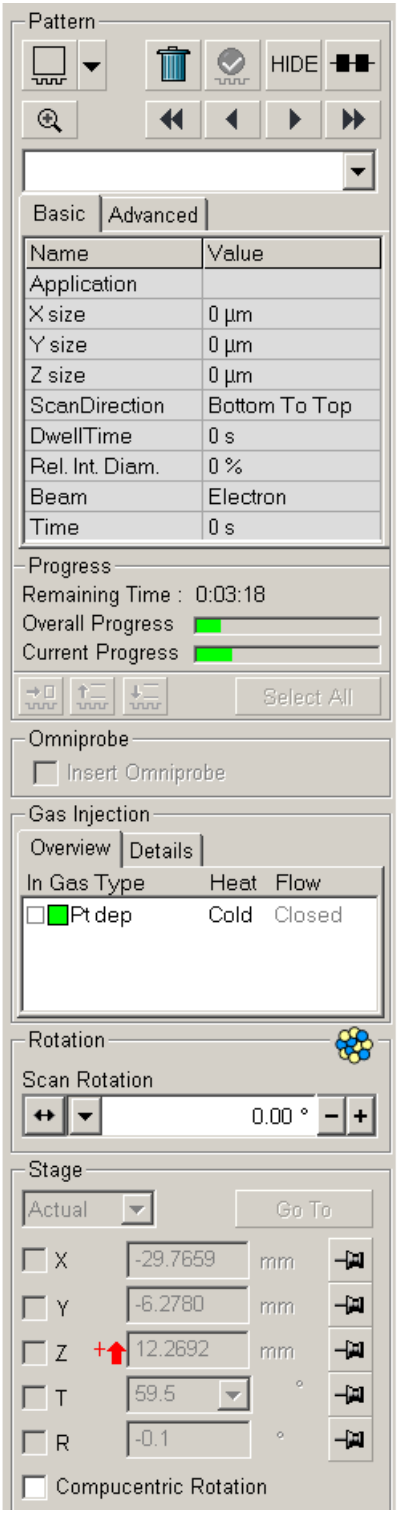
Charge Neutralizer (option)

The FEI Charge Neutralizer uses a low energy electron beam to control charging induced by the ion beam. This allows imaging of nonconductive materials and reduces electrostatic discharge-related sample damage. The functions are:

- Beam On: Turns on filament.
- Unblank: Blank and unblank electron beam.
- Filament current: from 0 to 1.43 A
- Grid voltage: from -5 v to +5 v
- Beam energy: from 28 eV to 200 eV
- Beam current: Display total beam current: changes in response to beam and grid voltages.

You can adjust the Filament current, Grid voltage, and Beam energy even while the beam is off.

Sample Preparation Page



This page is the combination of a part of **Patterning** page and a part of **Navigation** page. It is a dedicated page to control sample preparation, especially for TEM specimen preparations. The functions of each item are the same as described in the Patterning and Navigation pages. To use this page, it can reduce numbers of mouse clicks.

The **Sample Preparation Page** is divided into modules:

- **Pattern**
- **Progress**
- **Omniprobe**
- **Gas Injection**
- **Rotation**
- **Stage**

Pattern

Pattern shapes can be selected and drawn, their data entered and displayed with this module.

A shape can be selected by clicking on the PATTERN SELECTOR and the details filled in the pattern details list. The pattern is allocated a number relative to that shape and is displayed in the PATTERN LIST. When the PATTERN SELECTOR displays a yellow shape, that shape can be drawn in the selected quad with the small cross cursor. The pattern CONTROL CURSOR allows for selection between the drawn patterns in a quad. The pattern displayed via the PATTERN SELECTOR on the Patterning Page responds to the pattern highlighted in the working quad.

FIGURE 4-30 PATTERN SELECTION CONTROLS

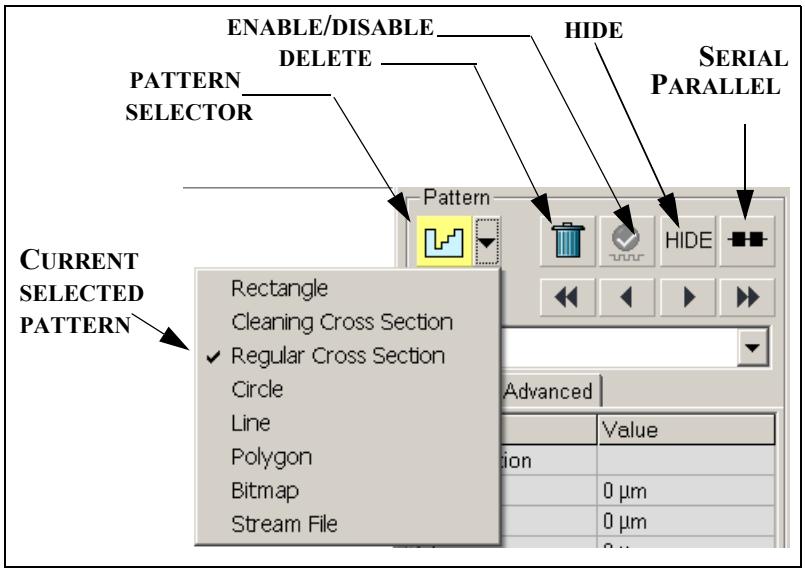
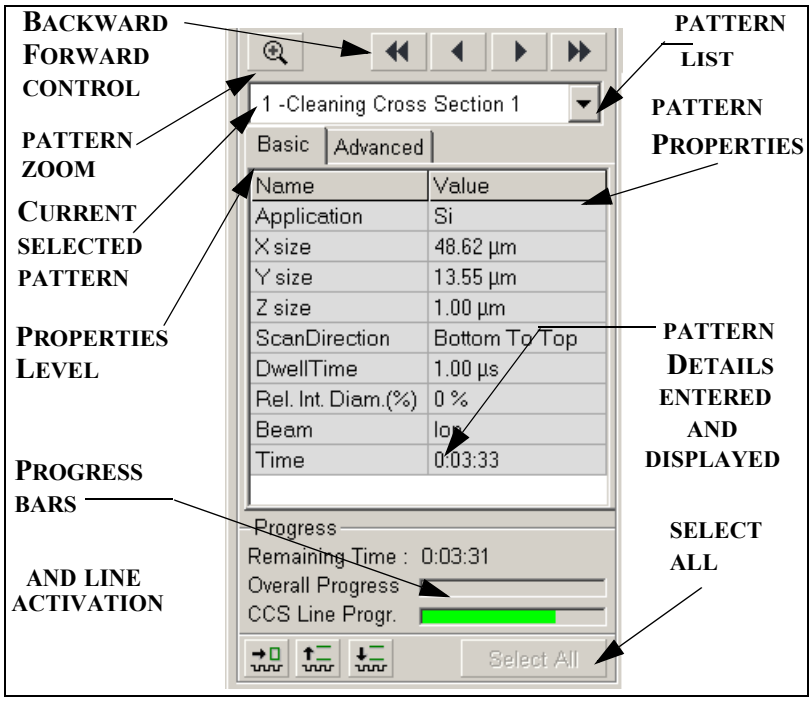


FIGURE 4-31 PATTERN PROPERTIES CONTROL



Progress

This module displays the overall and current progress (over time) of the active Patterning.

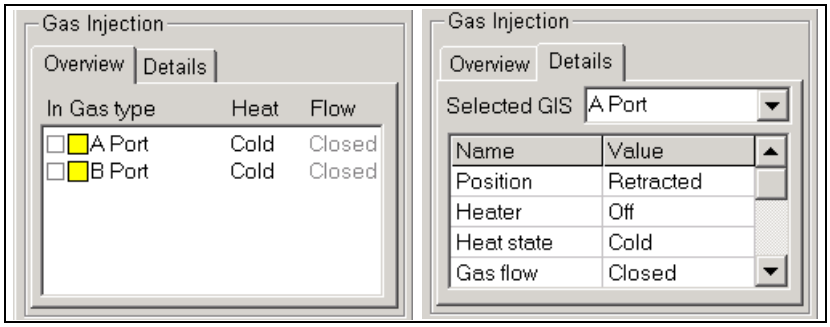
Omniprobe

The Omniprobe micro manipulator allows you to extract a TEM sample in situ. By selecting or deselecting the checkbox the Omniprobe needle can be inserted or retracted.

Gas Injection

The Gas Injection modules provides the capability to select the type of gas deposition or etch.

FIGURE 4-32 GAS INJECTOR OVERVIEW / DETAILS



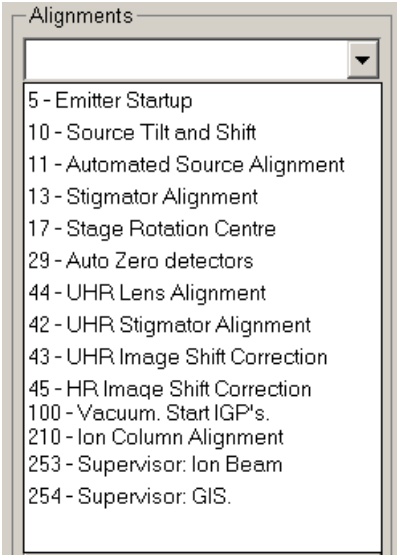
Overview Tab

On the OVERVIEW tab the checkbox to the left of the Gas Injector, labelled IN, is the toggle for in or out activation of the injector. The gas type is the gas assigned to the port. The HEAT status is a toggle between cold/hot, and the FLOW status is a toggle between open/closed.

Details Tab

Clicking on the DETAIL tab will display the characteristics of the active Gas Injector. The characteristics can be changed by entering the details to configure the injector.

Alignments Page


Alignments
5 - Emitter Startup
10 - Source Tilt and Shift
11 - Automated Source Alignment
13 - Stigmator Alignment
17 - Stage Rotation Centre
29 - Auto Zero detectors
44 - UHR Lens Alignment
42 - UHR Stigmator Alignment
43 - UHR Image Shift Correction
45 - HR Image Shift Correction
100 - Vacuum. Start IGP's.
210 - Ion Column Alignment
253 - Supervisor: Ion Beam
254 - Supervisor: GIS.

The **Alignments Page** is divided into modules:

- **Alignment**
- **Instructions**
- **No Step**
- **Status** (not seen here)

The Alignments Page is used to align the columns and determine fine tuning for the electromagnetic system. The software stores column parameters such as Gun Tilt X, Y, Gun Shift X, Y, and other data that ensures minimum image shift when focusing and stigmating images. When you click on the list box arrow, various available adjustments are displayed.

Alignments

Displays the list of Alignments available to the Supervisor.

Instructions

Displays key procedural information for the alignment Step in operation.

No Step

Steps range from 0 - # and indicate the actual step position during a alignment procedure.

Alignment allocation

The Alignments are not in procedural order, please refer to the Alignment Chapter for correct order of use.

Alignments allocated to Users:

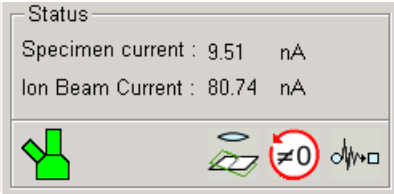
- 13 Stigmator alignment
- 17 Stage rotation centre

Alignments allocated to Supervisors:

the User alignments are available, plus:

- 5 Emitter Startup
- 10 Source Tilt and Shift Alignment
- 11 Automatic Source Alignment
- 29 Auto Zero detectors
- 42 UHR Stigmator Alignments
- 43 UHR Image Shift Correction
- 44 UHR Lens Alignment
- 45 HR Image Shift Correction
- 100 Vacuum: Start IGP’s
- 210 Ion Column Alignment
- 253 Supervisor: Ion Beam
- 254 Supervisor: GIS

Status



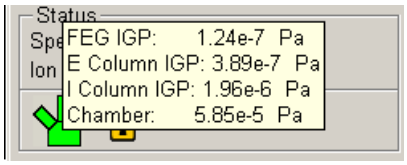
Status Module

This module can be found at the bottom of the most pages displaying important current system parameters and animated icons. These parameters may change due to the application being monitored at any time.

- **Specimen Current** shows the total current absorbed by a specimen.
- **Ion Beam Current** shows the primary Ion Beam current. The read out is only meaningful if the ion beam is blanked.
- **Chamber Pressure** shows pressures in the FEG IGP, E Column IGP, I Column IGP and specimen chamber. The vacuum status is also displayed with color icon, i.e., **Green**: pumped to the desired vacuum mode; **Orange**: transition between two vacuum statuses; **Grey**: vented.

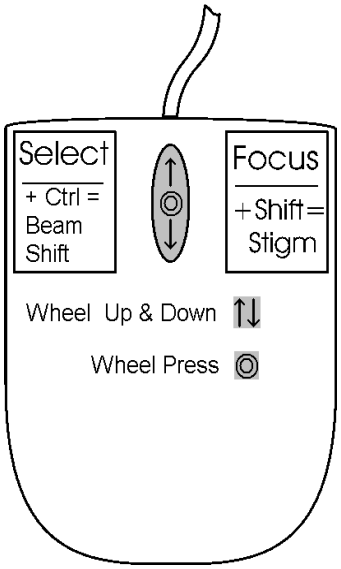
TABLE 4-5 STATUS ICON FUNCTIONS

Icon	Function
	Dual column and Chamber vacuum. Green columns and dark chamber = operating vacuum in columns but chamber is to atmosphere.
	Dual column and Chamber vacuum. Green columns and orange chamber = operating vacuum in columns and chamber pumping down.
	Dual column and Chamber vacuum. Green columns and chamber = operating vacuum reached in all sections.
	Stage axes lock. Closed lock indicates any or all axes locked.
	Dynamic Focus. Displays when Dynamic focus is on.
	Scan rotation. Displays when Scan Rotation is not zero.
	External. Displays when the External scan mode is operating.



- **Tool Tips** – Placing the cursor over the Status area will display the tool tip giving more precise information.

Entering Commands



Using the Mouse

The mouse buttons control imaging correction, selecting functions, scrolling magnification up/down and moving the stage in X and Y with TRACK mode. Mouse buttons are activated by a click or double-click or in conjuction with a key on the keyboard.

TABLE 4-6 MOUSE BUTTON FUNCTIONS

Button	Function
Left	Control Areas: Makes selection in control areas (single arrow cursor)
Left	Quad Areas/Full Screen: Double click activates the GET function and moves the stage position clicked-on to the center of the field of view. (single arrow cursor)
Ctrl + Left	Activates Beam Shift (quad ended arrow cursor)
Shift + Left	Moves selected pattern in one direction only
Right	Focuses image (double ended arrow cursor)
Ctrl Right	Lens Align
Shift +Right	Activates stigmator control (quad ended arrow cursor)
Shift + Wheel Up/ Down	Fine Control. Moving the wheel up increases the magnification. Moving it down decreases magnification.
Crtl Key + Wheel Up/ Down	Coarse Control. Moving the wheel up increases the magnification. Moving it down decreases magnification.
Wheel Press	Pressing the wheel like a button activates the TRACK mode for joystick -like movement over the sample surface, viewed fullscreen or in Quads 1-3 mode. In Quad 4 (CCD mode) the same function activates the Z movement. With the wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. This activity can be seen live in the CCD Quad 4 window.

To focus with the mouse, press the right mouse button and move the mouse to the left or right. Release the button to set the focus.

To Stigmate the image, press the Shift key and the right mouse button and move the mouse to the left or right, or up or down to correct. Release the buttons to finish.

Using the Keyboard

Dedicated Windows keys

Some keys are dedicated Windows keys:

TABLE 4-7 DEDICATED WINDOWS kEYS

Key	Function
ENTER	Equivalent of OK in a dialog box.
ESC	Equivalent for the CANCEL button.
TAB	Step key to highlight items in a dialog box.
ARROWS	Use to select between items in a group when in an edit box.
SHIFT + ARROWS	Move a selected pattern 1 pixel/ 2 pixels/ ... also during digital zoom. For accurate position.
CTRL + ARROWS	Pan (shift digital zoom area) (80%) of view in direction of arrow
ALT	Use ALT in combination with a character (underlined characters in the menu items) to open the pulldown menu in the active application. For example, pressing ALT and M at the same time brings up the Magnification pulldown menu.
ALT-TAB **(simulta-neously)**	Use these keys to show the last used program. Continue to press the TAB key (while holding down the ALT key) and applications that are resident are shown one by one. When the application you want is shown, release the ALT key and it becomes active again.
ALT-F4 **(simulta-neously**	Exit Application software and Windows.
DEL	Deletes an item in an edit box.
KEYPAD +/-	Magnification change of active quad.
Ctrl Keypad +/-	Digital zoom in / zoom out
PAGE next/ previous	Digital zoom in / zoom out

Function Key Short-cuts

Function Keys can be found at the top of the Keyboard and work either on their own, and with Shift or Ctrl keys.

TABLE 4-8 FUNCTION KEY SHORTCUTS

Key	Function
F1	On-Line Help (only switches ON)
F2	Photo
F3	Toggle Videoscope
Shift F3	Home Stage
F4	Electron Snapshot
Shift F4	Modulator
Ctrl F4	Ion Snapshot
F5	Toggle Quad Screen / Full Screen
Shift F5	Toggle Center Cross
F6	Toggle Pause / UnPause
Shift F6	Frame in Quad/Screen
F7	Toggle Reduced area On / Off
F8	Degauss
F9	Auto Contrast and Brightness
Shift F9	Link Z to FWD
F11	Auto Focus
Shift F11	Display Saturation
F12	Compucentric Rotation
Shift F12	Scan Rotation

Specific short-cuts on the Keyboard

These are Keyboard short-cuts for specific functions.

TABLE 4-9 SPECIFIC KEY SHORTCUTS

Key	Function
Ctrl + 0	centers X and Y stage axes to 0,0
Ctrl + A	select all (e.g. patterns)
Ctrl + C	copy the selected patterns from the active quad to a clipboard
Ctrl + D	Set Default Parameters
Ctrl + E	Sets bulk stage tilt to 0 degrees (E from Electron beam)
Ctrl + F	Sets FWD to Eucentric height (5 mm)
Ctrl + H	Set HFW
Ctrl + I	Sets bulk stage to 52^{o} (I for Ion beam)
Ctrl + M	Full frame
Ctrl + Shift + M	Record Movie
Ctrl + O	Preferences dialog
Ctrl + P	Prints to selected device
Ctrl + R	Restart Scan
Ctrl + S	Save
Ctrl + T	Active beam toggle; pauses the beam in active quad, switches to other beam type in same quad, activates this beam (if the former beam was also active; otherwise the beam is NOT activated). This functionality is only available for ebeam and ibeam.
Ctrl + V	paste the patterns from a clipboard into the active quad
Ctrl + X	move the selected patterns from the active quad to a clipboard
Ctrl + Z	Back Stage
Shift + N	Next Line (Ion Beam skips to next line)
Shift + P	Next pattern

TABLE 4-9 SPECIFIC KEY SHORTCUTS

Key	Function
Tab	Steps between controls
Ctrl + Tab	Steps between Quads
Ctrl + ,	Slower Scan
Ctrl + Shift + ,	Slow scan
Ctrl + .	Faster Scan
Ctrl + Shift + .	Fast scan
Ctrl +/-	Digital zoom in/ zoom out
Page Up/ Down	Digital zoom in/ zoom out
+	Increases magnification
-	Decreases magnification
*	Rounds off magnification to nearest whole number.
Arrows	Move one field (80%) of view in the direction of the arrow.

Patterning short-cuts on the Keyboard

These are keyboard short-cuts for patterning functions.

TABLE 4-10 PATTERNING SHORTCUTS

Key	Function
Ctrl + C	Copies the selected pattern
Ctrl + X	Cuts the selected pattern
Ctrl + V	Pastes the pattern from the clipboard into the active quad.
Ctrl+Alt+Left Arrow	moves selected pattern to the left
Ctrl+Alt+Right Arrow	moves selected pattern to the right
Ctrl+Alt+Up Arrow	Moves selected pattern up
Ctrl+Alt+Down Arrow	Moves selected pattern down
Esc	Deselects currently selected patterns
Shift + N	Next line
Shift + P	Next pattern
Ctrl+Shift+N	Previous line
Shift+ any Arrow key	Moves a selected pattern 1 pixel/ 2 pixels, also during digital zoom. Used for accurate positioning.

Hardware Interface Elements

LCD Monitors

The control software facilities and data are displayed graphically on one of the LCD monitors and are superimposed around and on the image. The other LCD monitor is used for optional or related programs.

The System Computer

The system computer activates the Start-up conditions of the Nova from a software base. Users Log-on to Nova from the Windows 2000 or XP base. Start-up and Shutdown of the Hardware are restricted to the FEI Service Engineer or an Authorized Supervisor, with the exception of the EMO buttons. See: User Manual, Chapter 3, System Operation.

Stage Controls

The Nova NanoLab stage is software/hardware controlled for five axes: X,Y, Z, Rotation and Tilt. See: User Manual, Chapter 6, Navigation.

Manual User Interface

The Manual User Interface (MUI) provides knobs to perform functions that can also be performed with the software:

- Imaging: Brightness and Contrast control
- Stigmator: X and Y control
- Magnification: continuous control of magnification up or down.
- Shift: X and Y Image shift control
- Focus: Coarse and fine control

TABLE 4-11 MUI SOFTWARE CONTROL EQUIVALENTS

MUI	Software Equivalent
IMAGE CONTRAST BRIGHTNESS	Contrast and brightness adjusters on pages, or Auto Contrast and Brightness Icon button on Tool bar.
STIGMATOR	Shift + right mouse button
MAGNIFICATION	+/- keys on numeric keypad. Shift + Mouse wheel for fine control. Ctrl + Mouse wheel for coarse control. **Additional operation combinations:** Ctrl + Magnification wheel for increase/decrease Digital zoom.

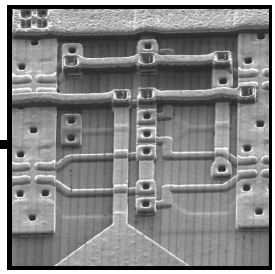
TABLE 4-11 MUI SOFTWARE CONTROL EQUIVALENTS

MUI	Software Equivalent
BEAMSHIFT	Shift + Left mouse button **Additional operation combinations:** Ctrl + beam shift: clockwise moves viewport to left (shift x) and down (shift y). Sensitivity depends on set sensitivity in Preferences.
FOCUS	Right mouse button

Control Sensitivity

Sensitivity can be adjusted for all controls except Magnification by presetting the various sliders via the Preferences, Sensitivity Tab.

5 WORKING WITH NOVA NANOLAB



This chapter describes the essential parts of the system from a How-to-Use oriented point of view for Supervisors and Users. These procedures assume you have at least read and are familiar with Chapters 3 (System Operation) and 4 (The xT User Interface).

It begins with default set-up conditions to check before using the system and includes procedures for the following:

- Starting your session
- Ending your session
- Preparing the sample
- Exchanging the sample
- Obtaining and optimizing images
- Recording images
- Printing
- Save, Save As, Open, Import/Export
- Use of Detectors
- Use of Beam conditions
- Use of Preferences
- Patterning/Milling/Sections
- Use of the GIS
- Use of the EPM
- Use of Measurements
- Use of Annotations

For Administrators there is a management software for organising Supervisors and Users. This is described at the end of this chapter under the title:

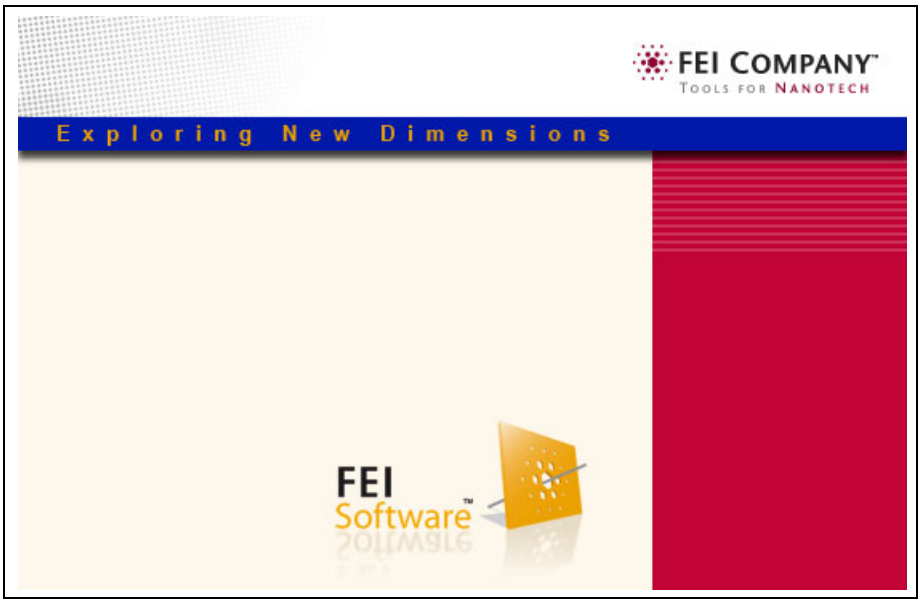
- FEI User Management Software

Starting the xT-UI

Click on START UI in the Server Dialog to start the User interface.

The xT splash screen displays while the software is loading:

FIGURE 5-1 STARTUP XT SPLASH SCREEN



After the UI has loaded, Log-on as Supervisor or User.

A dialog for loading your conditions will display and then the User can proceed to start the sources and operate the Nova.

Default Conditions at xT Start-up

The following system defaults apply upon first startup of the Server, not when a new user logs in.

The system starts up with the E-Beam selected.

TABLE 5-1 XT STARTUP CONDITIONS

Parameter	Sirion Electron Column	Sidewinder Ion Column
Resolution mode	Mode 1	N/A
Magnification	100 X	250 X
Working distance	5.0 mm	16.5 mm
Focus	Eucentric height	Eucentric height
Spotsize	3	1 pA aperture
kV	5 kV accelerating voltage	30 kV beam voltage
Filter	Slow: Integrate 1, Average 4 Fast: Integrate 64, Average 4	Average 2
Detector	SED	CDEM
Column Apertures	30µm (manual change)	Drives to normal imaging aperture position to protect the sample
Page	Beam Control	Beam Control

Guide to System Settings

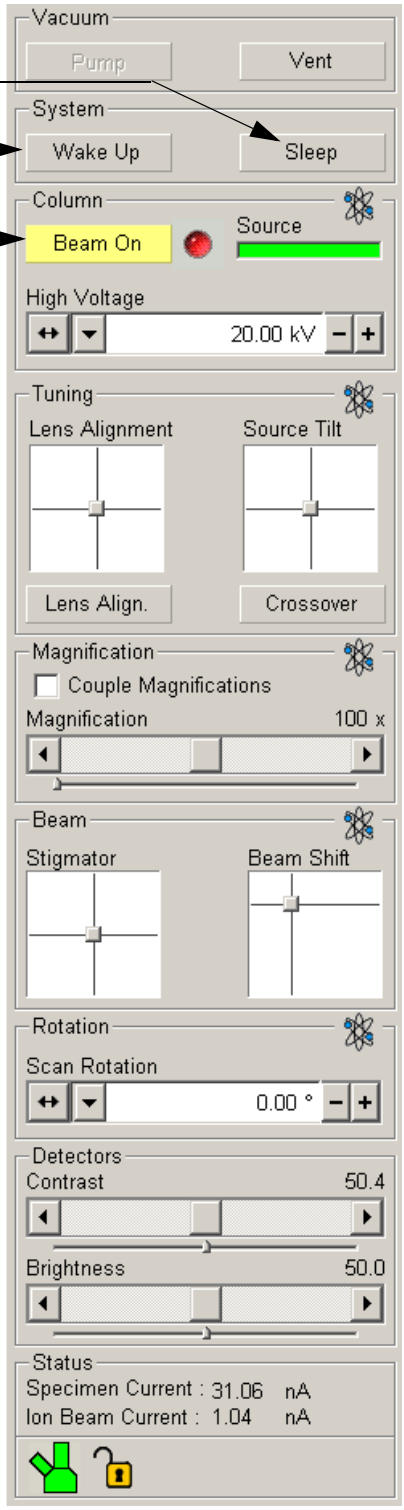
Operations Checklist

Follow these general guidelines until you become more familiar with system operation. Later, you can customize these settings to meet your sample needs.

TABLE 5-2 NOVA NANOLAB SETUP CONDITIONS

Adjustment	Location	E- Beam Setting	Ion-Beam Setting
Cursor focus	Click on Quad required	Any Quad or Screen E-Beam functions.	Any Quad or Screen I-Beam functions.
kV	Beam Control page	Select kV relative to sample type: low kV for nonconductors high kV for conductors Example: IC sample = 5 kV	30 kV for fast milling 5kV for cleaning
Spotsize	E-Beam dropdown	Spot 3	100 pA 30 kV
Scan	Toolbar button or Scan menu	Medium resolution Fast scan	Medium resolution Fast scan
Magnification	Magn menu or MUI	20 X	200 X
Eucentric Height	Navigation Page/ Stage	5 mm	16.5 mm
Averaging	Toolbar button	No Averaging or Average 4.	No Averaging or Average 4
Contrast and Brightness	Detector Adjusters or MUI	With Contrast at zero value adjust Brightness to just show a change in intensity to the screen. Increase the Contrast to produce a reasonable image on screen. Increases in Brightness and decreases in Contrast produces softer images. The reverse produces sharper images.	Same as E-Beam

Beginning Your Session



Usually, the Nova remains on (with the electron column emitter on) but with the ion column LMIS off. High voltage (HV) is typically off for both columns.

Follow the steps in TABLE 5-3 below when beginning the first work session of the day. Throughout the day, the Nova stays on from session to session.

TABLE 5-3 BEGINNING YOUR SESSION

Step	Action
1	Enter your name and password in the Login dialog box for Windows 2000 or XP accessed at startup. Start the application.
2	Click open the **Beam Control** page. Check and set the conditions recommended in the **Nova Setup Conditions,** previous table.
3	If a sample is not already in the sample chamber, insert one according to the directions for loading samples (found later in this chapter).
4	Click WAKE UP if the System module indicates it is in SLEEP mode.This typically take 5minutes. This process will start the High Voltage on both columns and open both isolation valves. The Beam that is primary is indicated by the logo in the column module (in this case Electron). The High Voltage slider can be adjusted to that required for the primary Electron beam. By switching beams on the Tool bar the **Beam Control** page will revert to the other beam (in this case Ion) for adjustment to be made.
5	Focus the cursor on Quad 4 and turn on the CCD camera. This is to monitor the positioning of the sample relative to other items in the chamber.
6	Focus the cursor on Quad 1 and click UNPAUSE on the tool bar to release Quad 1 to the scanning of the E-Beam. Click on AUTO-CONTRAST AND BRIGHTNESS in the **Tools** menu, or control the CONTRAST and BRIGHTNESS from the DETECTOR module found on most pages.
7	Focus and stigmate the image using the mouse or MUI. Click on the Z-FWD icon in the tool bar to calibrate the physical position of the sample.

TABLE 5-3 BEGINNING YOUR SESSION

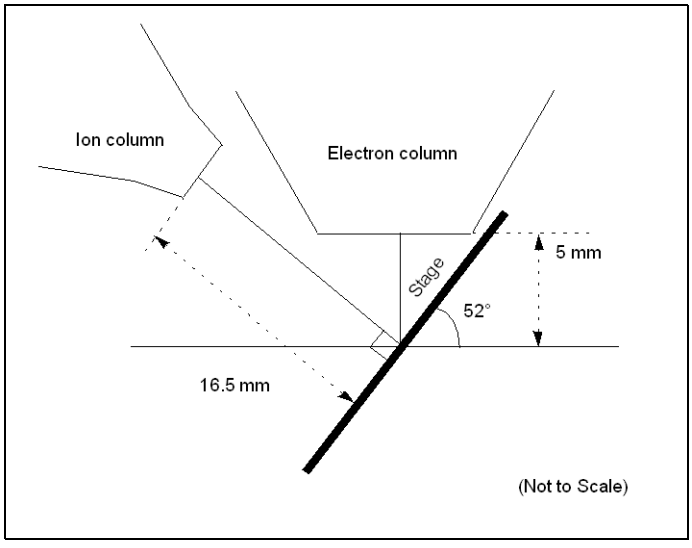
Step	Action
8	Go to the **Navigation** page and set the Z value to 5 mm and click on the GOTO button. A fairly flat sample should now be at the eucentric height. To check this for more topographical samples, rock the tilt control by 3^{o} either way over zero (-3 to +3) by entering the values in the T box and clicking on GOTO. Adjust the mechanical Z on the stage to correct any small offset due to varying height on the sample surface.
9	Focus the cursor on Quad 2 and click UNPAUSE on the tool bar to release Quad 2 to the scanning of the I-Beam. Control the CONTRAST and BRIGHTNESS from the DETECTOR module found on most pages. Focus and stigmate the image via the mouse or the MUI.
10	Focus back on Quad 1 and unpause the SEM scanning. While observing the electron beam image in quad 1 set the tilt control to 52^{o} by entering the value in the T box (STAGE module) and clicking on GOTO. Save the stage condition in the LOCATION list in the STAGE module.

At this point you will be able to image the Electron Beam image in Quad 1 and the Ion Beam image in Quad 2 at the eucentric height, 52^{o} tilt, and ready to search the area of interest necessary for Ion Beam milling or patterning.

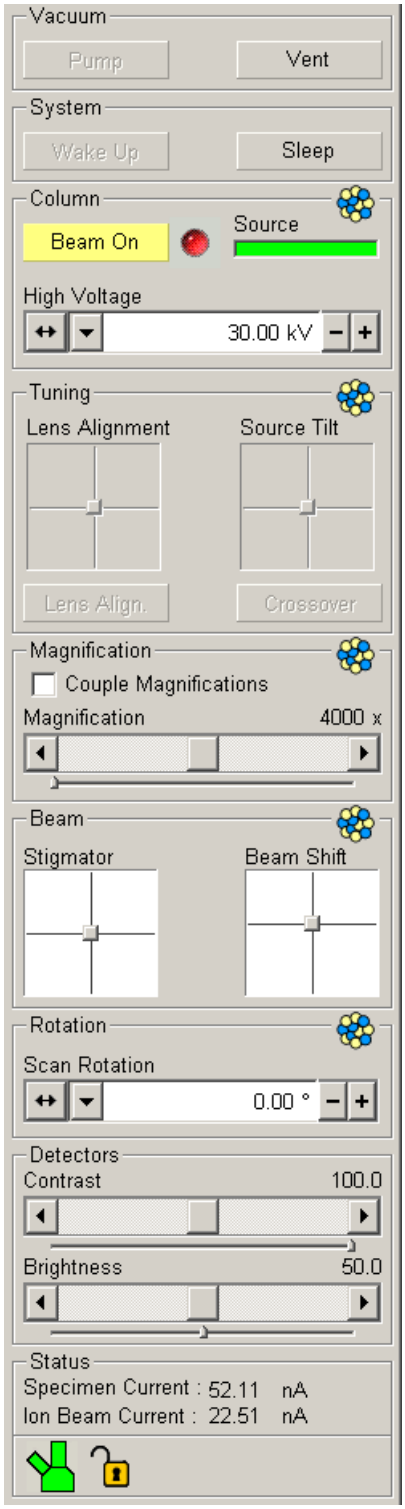
Importance of Beam Coincidence

The Electron and Ion columns are mounted as illustrated in the following figure, which shows the stage tilted to 52°. Coincidence of the beams occur at the eucentric tilt axis.

FIGURE 5-2 RELATIONSHIP OF THE TWO COLUMNS



Ending Your Session



When you are done with your session, log out, leaving the system ready for the next operator.

TABLE 5-4 ENDING YOUR SESSION

Step	Action
1	Click off the BEAM ON buttons (for the electron and ion beams). If the system will not be used any more that a day, click the SLEEP button to turn off the ion column SOURCE. (The buttons should turn gray while the Wake up button becomes active.)
2	For Supervisors only: Go to the **Navigation** page, unlock or lock any stage conditions depending whether the stage is to move on vent or not. Vent the chamber via the VENT button on the **Beam Control** page and remove your sample. The Vent cycle includes an automatic safety positioning of the stage, unless the stage is locked. Pump the system down by clicking on the PUMP button on the **Beam Control** page.
3	Log Off the xT User Interface by selecting Log Off from the File Menu.

Preparing the Sample

Needed Tools and Supplies

You will need the following tools and supplies:

- Various Allen and Torx wrenches
- Class 100 clean room gloves
- Sample stubs or wafer holders
- Prepared sample

NOTE: Always wear lint-free clean room gloves when reaching into the specimen chamber or loadlock to prevent leaving oils, dust, or other contaminants inside the loadlock.

Preparing the Sample

The sample material must be able to withstand a high vacuum environment without outgassing. It must be clean. Oil, dust or other materials may cause sample charging or contaminate the chamber, which could hinder or even prevent evacuation.

Mounting the Sample on the Holder

If you are using a wafer piece or other sample, attach it to the sample holder using any suitable SEM vacuum-quality adhesive – liquid silver, carbon or double-sided tape. The sample must be electrically grounded to the sample holder to minimize sample charging. If using double-sided tape, make sure the sample is attached to the holder in some way for grounding.

NOTE: The sample holder is not directly grounded to the chamber ground because it is connected to the BNC feed through on the chamber door. This is to allow measurement of sample current.

If the sample is nonconductive (plastic, fiber, polymer, or other substance with an electrical resistance greater than 10^{10} ohms), the sample may be coated with a 200-300 angstrom layer of carbon. Rough surfaced samples must be evenly coated from every direction. This conductive layer minimizes sample charging, increases beam stability and improves image quality.

Maximum Sample Dimensions

The xT Nova NanoLab can accommodate up to 6" wafers.

CAUTION! Store samples and sample holders in a dry nitrogen storage cabinet. Dust on samples can get drawn into the electron column, degrading imaging and requiring an FEI Customer Service call to correct the problem.

Exchanging samples

To exchange samples loaded onto the standard holder or Sample Vise proceed with the steps in the following table.

TABLE 5-5 EXCHANGING A SAMPLE

Step	Action
1	Click off the BEAM ON button on the **Beam Control** page. Go to the **Navigation** page, unlock all stage conditions if necessary.
2	Vent the chamber via the VENT button on the **Beam Control** page. The Nova 200 stage remains at the set Z position. The Nova 600 stage moves to it's lowest Z position.
3	Open the door and exchange the sample. On the Nova 200 stage check that the height of the new sample does not exceed that of the previous sample by way of the Sample Height Adjuster Tool. If the sample height is higher then turn down the mechanical Z to suit the Adjuster Tool. On the Nova 600 stage use the CCD live image to check if sample height is OK. The stage moved to the lowest position when vented; adjust stubholder height if necessary.
4	Close the door and pump the system down by clicking on the PUMP button on the **Beam Control** page. When the vacuum is correct follow the steps referred to in 'Beginning Your Session'.

TEM Grid sample handling (option)

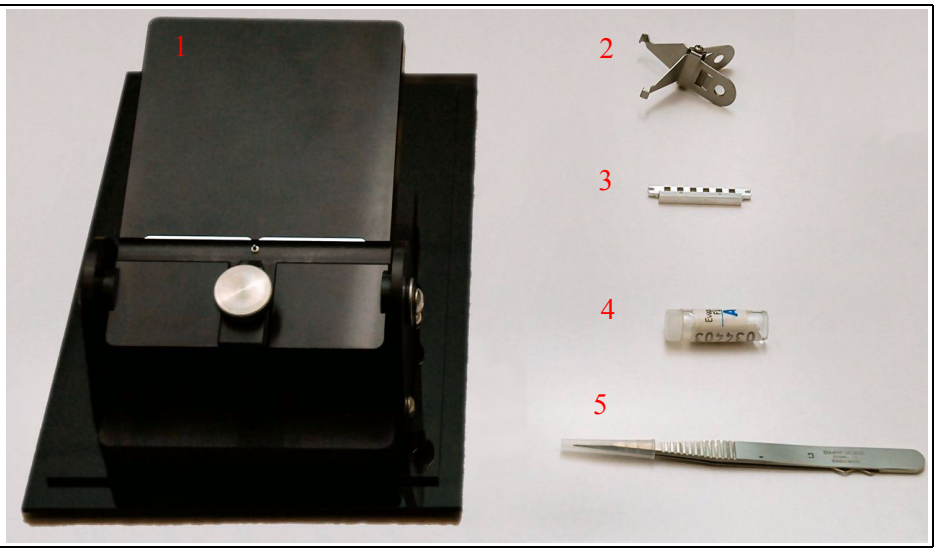
Loading TEM grids

A rowholder containing TEM grids or pre-thinned samples mounted on ‘C’ shaped grids can be mounted in the Sample Vise.

NOTE: Use gloves whenever handling vacuum parts, work clean preferably in the laminar flow cabinet. To make work easier, the mounting base can be placed under an optical microscope in the flow cabinet.

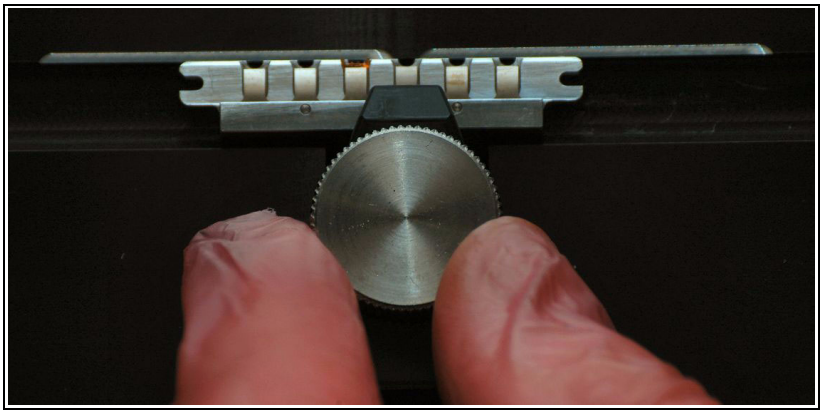
FIGURE 5-3 REQUIRED MATERIALS

1) Specimen table or Mounting Base
2) Hand clamp
3) Row holder
4) TEM sample
5) Pair of tweezers



1. Pickup the row-holder, and hold over the slot in the mounting base. Line up the location to be loaded (the tip of the leaf spring finger) with the central loading region on the mounting base. When the position is lined up, the row-holder will slide down over the pin in the slot of the mounting base (there are holes through the row holder under each leaf spring finger that the pin slides through).
2. Clamp the row-holder on the mounting base using the thumbwheel screw. The spring of the row-holder will now open.

FIGURE 5-4 CLAMP THE ROW HOLDER ON THE TABLE



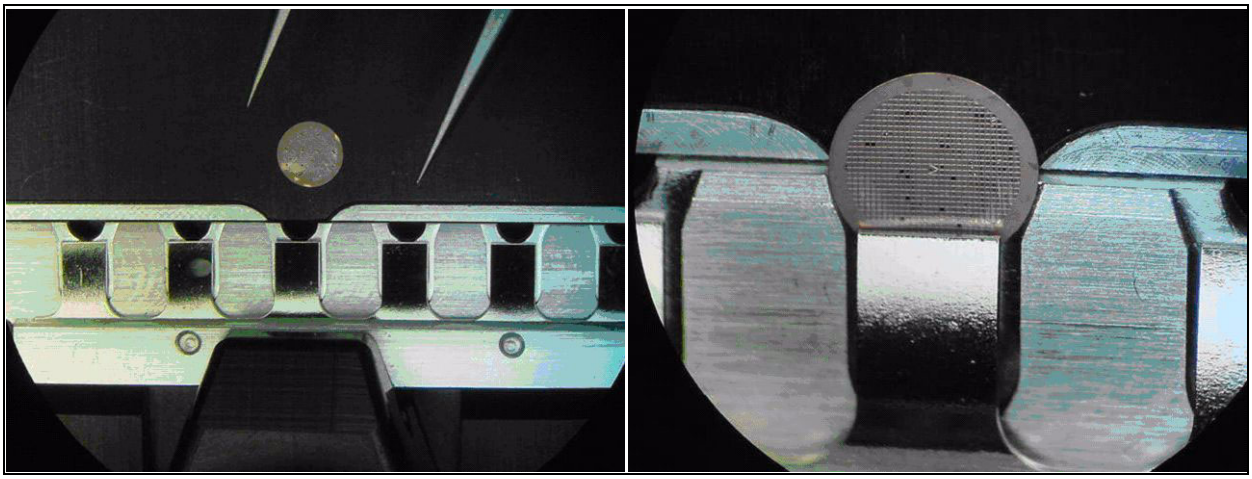
CAUTION: There is no need to tighten the thumbwheel screw too hard. It is only used to make sure the row-holder is held against the bottom of the slot, so the pin lifts the leaf spring finger far enough to allow sample loading.

3. Locate the TEM sample or grid to be loaded and put it on the mounting base, using either mechanical or vacuum tweezers.

NOTE: On either side of the central dark loading region, the slot edge of the mounting base is cut away to allow tweezer access from the side.

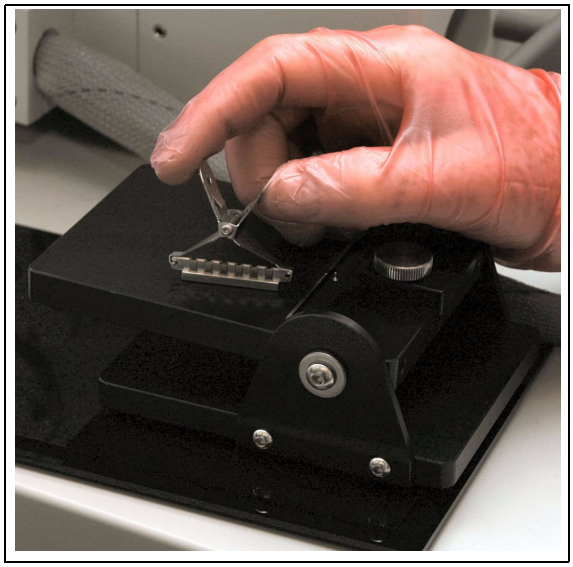
4. Manoeuvre the sample under the clamping spring of the center position of the row-holder.
5. Gently release the clamping screw. The specimen is now clamped by the row-holder itself.

FIGURE 5-5 TEM SAMPLE / TEM SAMPLE MOUNTED



6. Remove the row-holder from the mounting base by grasping both ends with the hand clamp or a gloved hand and lifting.

FIGURE 5-6 USE OF THE HAND CLAMP

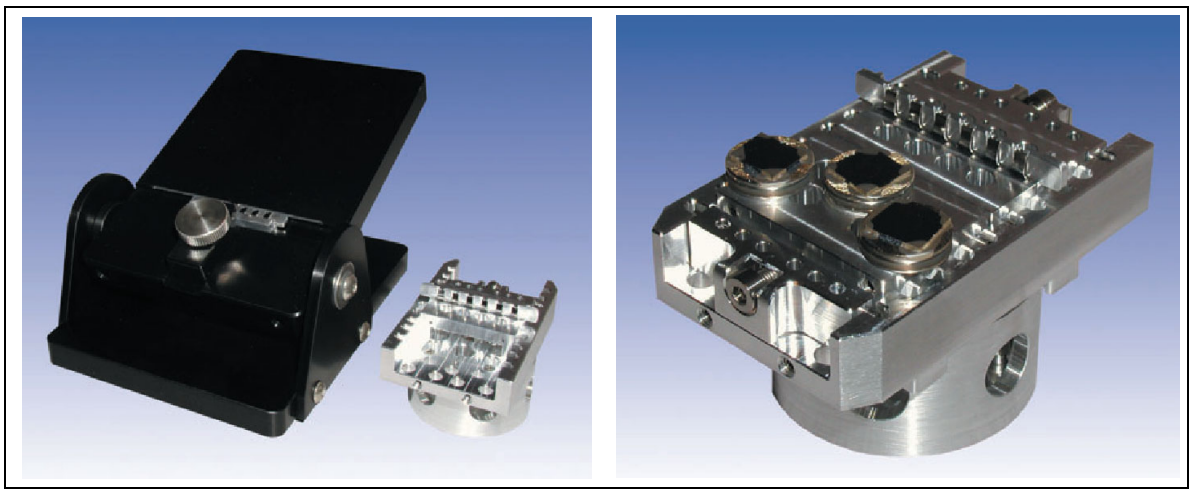


7. Using either the hand clamp provided or a gloved hand, place the row-holder into the Sample Vise.

UMB holder

On a Nova NanoLab use the UMB holder, to hold the sample mounts.

FIGURE 5-7 UMB HOLDER WITH MULTI-STUB MODULE

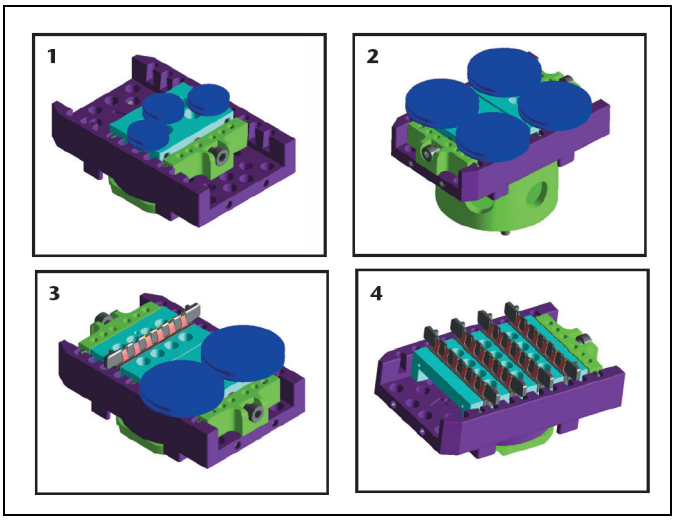


The basic UMB stub holder kit comes with a multiple-stub module (1) that can hold three 1/2" or two 1" standard stubs. An additional stub module can be added to hold a full array of four 1" stubs for high-volume sample work.

A FIB/TEM holder kit (2) for UMB can be added to provide FIB/TEM sample-holding capability to the UMB. The combination of the UMB stub holder kit and FIB/TEM holder kit (3) allows both TEM grids and stubs to be loaded simultaneously in the UMB, an ideal configuration for in-situ sample manipulation.

A high-volume FIB/TEM kit (4) is available to augment the FIB/TEM holder kit. This high-volume option contains a full-size UMB module and four row holders to hold a total of 24 TEM grids.

FIGURE 5-8 OPTIONS FOR THE UMB HOLDER KIT



Obtaining an Image

How an Image is Produced

All scanning beam microscopes produce images with the same fundamental technique: the primary beam is scanned across the sample surface in a regular pattern called a *raster*. Normally, this raster consists of a series of lines in the horizontal (X) axis, shifted slightly from one another in the vertical (Y) axis. Simultaneously, a spot of controllable brightness is scanned over the display area of a monitor in the same pattern.

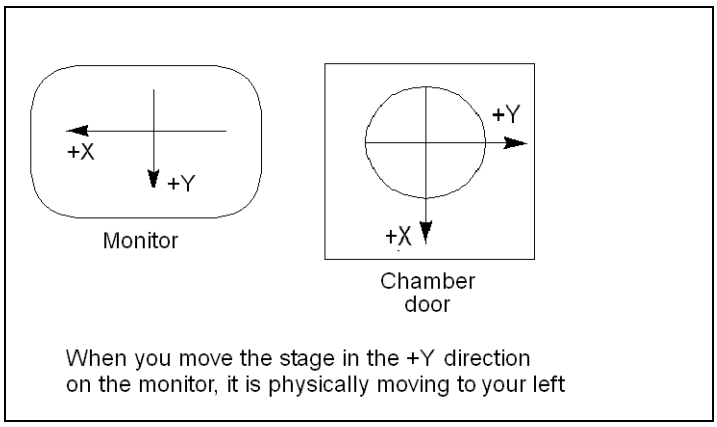
The signal, emitted by the sample surface as it is illuminated with the primary beam, is collected by the chosen detector, amplified, and used to adjust the brightness of the spot.

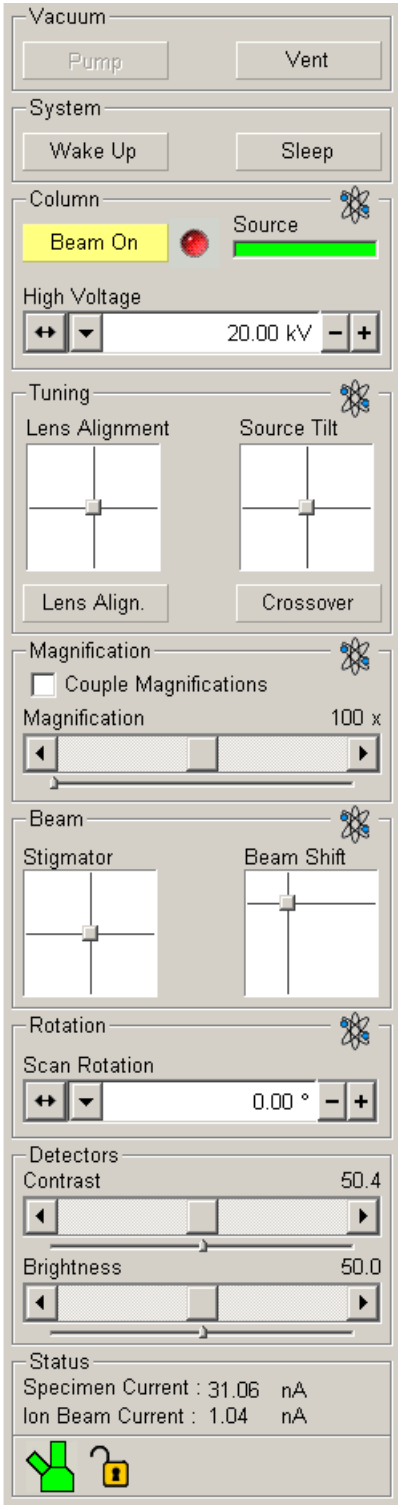
Relationship Sample to Image

The spot must be scanned across the screen very rapidly so that the human eye sees it as a continuous image and not a moving spot. Because most beam scanning takes place at rates too slow to provide the illusion, the slowly gathered image is loaded into computer memory. This stored image is displayed at a fast scan rate, but updated only at the beam scan rate.

The raster consists of many (typically one million) individual locations (pixels) that the beam visits. As the beam is scanned, the signal emitted by the sample at each beam position is measured and stored in the appropriate digital memory location. At any time after the beam scan, the computer can access the data and process it to change its properties, or use it to generate a display. Because of this direct correspondence, the image displayed on the monitor is directly related to the sample surface. The sample surface is rotated 180° with respect to the front of the loadlock.

FIGURE 5-9 RELATION BETWEEN VIEWED IMAGE AND STAGE





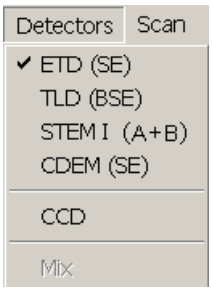
Set up for Imaging

The following assumes that the source is already on and is set to operate when the BEAM ON button is pressed. Use the following procedure to obtain an image of the specimen with either beam:

TABLE 5-6 OBTAINING AN IMAGE

Step	Action
1	On the **Beam Control** page for the active beam, click on the BEAM ON button, found in the COLUMN module, to ramp up the high voltage.
2	Focus the cursor on Quad 1, 2 or 3 and click UNPAUSE on the tool bar to release the chosen Quad. An image will appear in the focused Quad (1,2 or 3). Focus the image with the mouse or MUI.
3	Click on the Z to FWD icon button on the Tool Bar.
4	Click on AUTO-CONTRAST AND BRIGHTNESS in the **Tools** menu, or control the CONTRAST and BRIGHTNESS from the DETECTOR module found on most pages, or from the MUI.
5	Adjust to a suitable magnification via the Tool bar MAGNIFICATION list box, or the keyboard plus and minus keys, or from the MUI. Correct the focus and astigmatism.

Detectors for Nova NanoLab



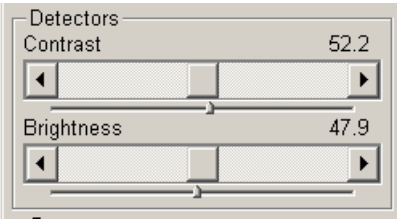
Imaging Detectors (general)

The Detector menu shows the imaging detector(s) installed on your system for imaging. A tick marks the active detector.

The I-Beam has one active mode for milling and imaging, whereas the E-Beam has Mode 1 for low magnification 'Search' conditions, Mode 2 for 'High Resolution' imaging and Mode 3 for 'Analytical' work.

Detector selections are tied to the choice of the active beam. The system always reverts to the last detector used for that beam.

- TLD-S can be used with either Beam in Mode 1 or 2.
- TLD-B, TLD-C, and TLD-D are E-Beam specific for Mode 2 with magnifications greater than x1000.
- The SED is only used with either beam in Mode 1 or Mode 3.
- CDEM-I is used with the I-Beam and CDEM-E can be used with either beam. (Optional).
- The STEM is used with the E-Beam in Mode 1, 2 or 3.



When you select a detector, the contrast and brightness adjusters default to the settings last used for that detector.

TABLE 5-7 DETECTOR MODES

Detector Type	Name	Detection Mode	Default range
Thru-the-Lens Detector	TLD-Secondary Electron TLD-Backscatter Electron TLD-Charge Reduction TLD-Down-Hole Visibility	Mode 1, 2 or 3 } Mode 2	S = +150 V (Mode 1 or 3) S = +50 V (Mode 2) B = -150 V C = 0 V D = +150 V
Secondary Electron Detector	ETD-Secondary Electron ETD-Backscatter Electron	Mode 1or 3	S = -150 to +300 V
Continuous Dynode Electron Multiplier (Optional)	CDEM-Secondary-Ion CDEM-Secondary-Electron	Mode 1	Bias Grid = +300 to -300 Front End Voltage = +300 to -2500

TABLE 5-7 DETECTOR MODES (Continued)

Detector Type	Name	Detection Mode	Default range
Scanning Transmission Electron Detector (Optional)	STEM 1-Transmitted Electron	Mode 1, 2 or 3	segment A segment B segment A plus B segment A minus B
Scanning Transmission Electron Detector (Optional)	STEM 2-Transmitted Electron	Mode 1, 2 or 3	Bright Field (BF) Dark Field (DF) High Angle Annular Dark Field (HAADF) Partial HADF segments (HADF1) Complimentary HADF

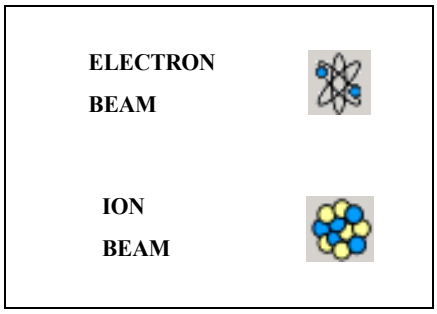
Changing Detectors or Custom mode

All detectors, when active, show live-time operation except while Patterning is in operation. Therefore when changing detectors or changing conditions, such as on the Detector Page for the Custom modes, the active detector(s) will show the changes in live-time.

Beam indicators

On the Detector Page a similar dialog module will appear for each detector. At the time the dialog opens a beam indicator icon will be present in the dialog to show the beam in use.These change in the Detector Page module automatically as different Quads are chosen to display different detector images

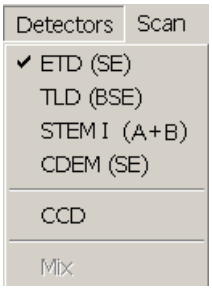
FIGURE 5-10 BEAM INDICATORS

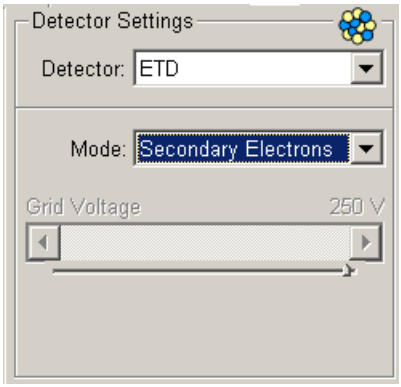


On hold changes when Patterning

During the patterning process the Detector Menu is still in use, but setting changes will not become active until Patterning has stopped or been interrupted. The Custom modes in the Detector Page are still available. Typical times when changes may need to be made to a detector while patterning is when Snapshot or Grab Frame will be used during a patterning session. These facilities can be setup in advance. When patterning has stopped the last scan detector and scan conditions will be active.

Standard Imaging Detectors



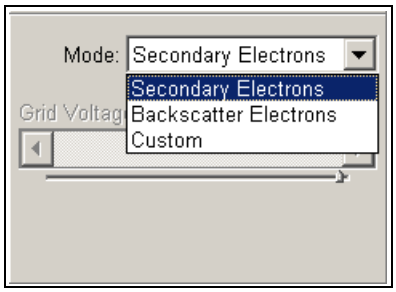


ETD

The Everhart Thornley (ETD) is a scintillator type detector monitoring secondary electrons generated for collection outside of the lens. It is mounted in the chamber above and to one side of the sample. It is a photo-multiplier detector and only works in Mode 1 and Mode 3.

The ETD detector can be used by default as a SE or BSE detector. The ETD switches off during venting of the specimen chamber. The normal secondary electron operating setting for imaging is +300 V and -150V for backscatter electron collection. These settings are ordinarily preset at the factory but you may need to adjust the Custom condition for optimum imaging on individual specimens

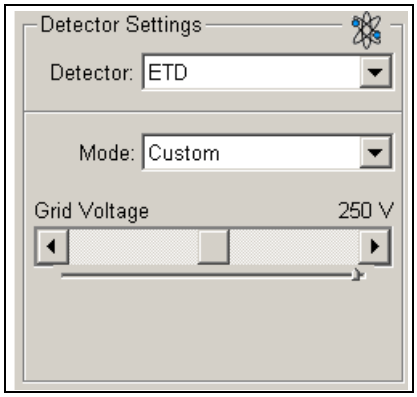
FIGURE 5-11 ETD DETECTION CHOICE



ETD Custom settings

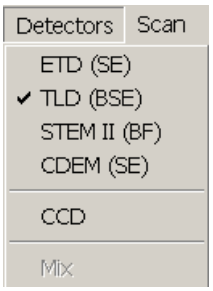
Clicking on the dropdown list arrow will reveal the Custom mode at the end of the list. Clicking on the Custom mode will activate the adjuster(s). These are to vary the custom mode of the detector. When grid bias is negative, secondary electrons are repelled from the ETD detector and only backscattered electrons are detected. The biasing capability is from -150V for only backscattered electrons to +300V for secondary collection.

FIGURE 5-12 ETD CUSTOM MODE



Selecting any ETD mode will set that mode label in the ETD position in the Detector menu. All changes made are visualised in live-time (except while Patterning), the detector responds immediately.

TLD



You can choose up to four defaulted modes and one custom mode from Thru-the-Lens (TLD) detector on the Detectors menu. The current choice is displayed next to the TLD label in the Detector menu. The TLD detector works in Modes 1, 2 and 3.

Mode 1 and 3

In Mode 1 and 3 the TLD will only show Secondary and Backscatter Electrons as the choice. Custom is also available to work with a grid voltage between the two conditions of electron collection. To vary the grid voltage for this detector first click on custom mode and this will activate a variable control for the detector.

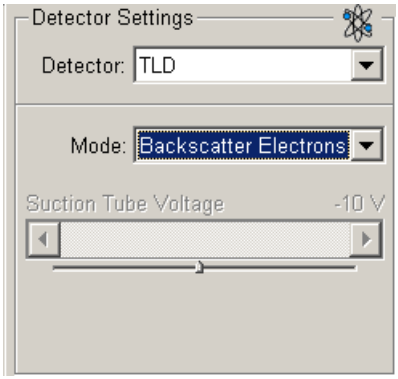
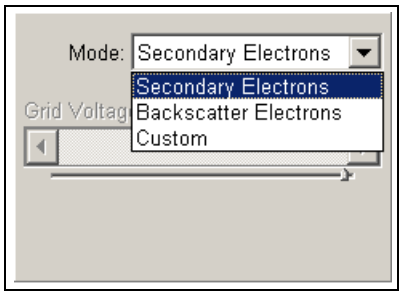


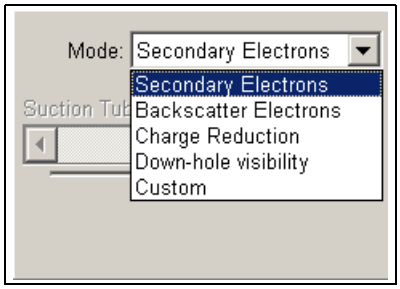
FIGURE 5-13 MODE 1 & 3 TLD CHOICES



Mode 2

In Mode 2 the TLD shows all four defaulted collection choices including a custom mode.

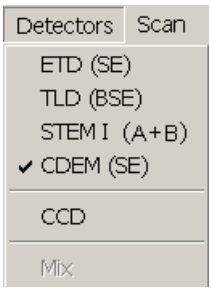
FIGURE 5-14 MODE 2 TLD CHOICES

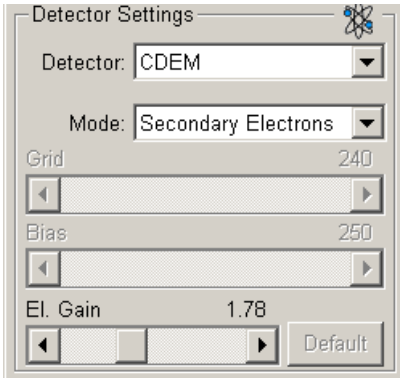


TLD Custom settings

Clicking on TLD Custom while in either Mode 1,2 or 3 will display an adjuster to vary the custom mode of the detector. For Mode 1 and 3 this will be labelled ‘Grid Voltage’, and for Mode 2 ‘Suction Tube Voltage’. The TLD detector can have the voltage changed within the lens to give custom variations of electron collection. When grid voltage is negative, low energy secondary electrons are repelled from the TLD detector and only backscattered electrons are detected. When grid voltage is positive, low energy secondary electrons are collected by the TLD detector. The biasing capability is from -150V for backscattered electrons to +150V for secondary collection.

Optional Imaging Detectors

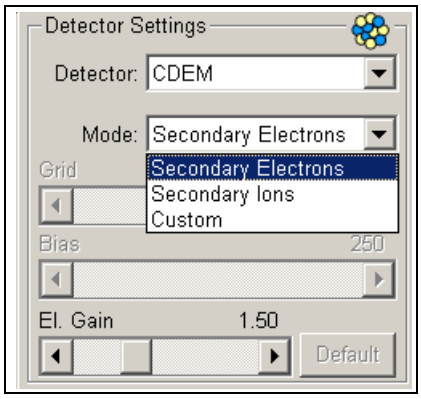




CDEM (Option)

The Continuous Dynode Electron Multiplier (CDEM) is a charged particle detector mounted near the end of the ion column. The CDEM and pre amplifier collect and convert secondary electrons or ions to form a imaging signal.

FIGURE 5-15 CDEM DETECTION CHOICE



CDEM Custom settings

Clicking on Custom mode will display the sliders for adjusting Grid, Bias and Electrical Gain to vary the custom mode of the detector.

The Electron beam and Ion beam modes have their separate Detector modules distiguished by the beam indicator for Electron or Ion.

All changes made can be visualised in live-time (except while Patterning), the detector responds immediately. Changing aperture or spotsize using the menus or custom controls affects the contrast of the secondary particle detectors. Contrast is reduced automatically when you change the aperture to a larger beam current.

TABLE 5-8 CDEM DETECTOR RANGE CONDITIONS

Mode	Grid Voltage Range	Bias Voltage Range	El.Gain range
Secondary Ion/Electron	-500 to +500v	-2000 to +500 V	0 to 4.98

Custom effect on Beam Shift

Large changes to the custom conditions on biased detectors such as the TLD, ETD and the CDEM could cause beam shift, which in turn will affect the coincidence of the two beams. Therefore it is not advisable to change custom conditions during a patterning session. If coincidence is affected then re-calibration will be necessary before starting to pattern.

STEM 1 (Option)

The STEM 1 detector is a two segment solid-state device mounted underneath a Grid holder assembly. Since the STEM 1 Detector is mounted on the stage it can be used at any available working distance preferably close to the lens for high resolution or at the eucentric position for simultaneous use of EDX. The mounting pin below the detector locates into the standard conical single stub mount provided with each stage. The locking screw should be tightened to stop unnecessary rotation of the detector. The plug located at the end of the cable from the detector is connected to the solid state amplifier (usually on the back right port).

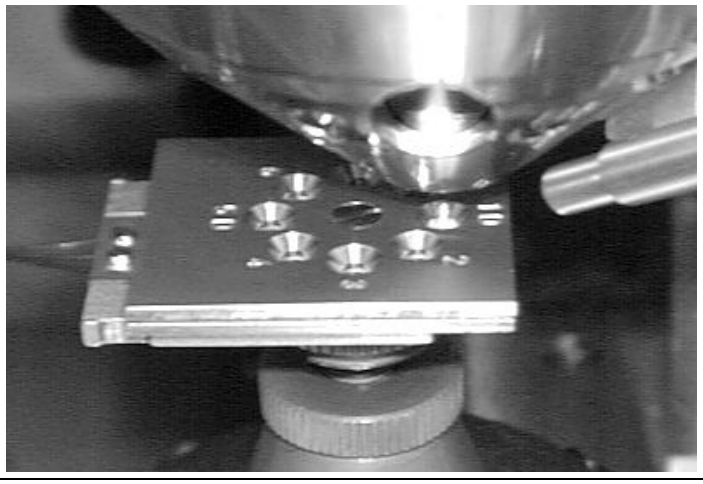
The STEM holder has 8 positions for sample grids. Two of these positions are specifically for Darkfield observation and are marked accordingly (1D, 5D). For Darkfield observation the chosen sample grids should be loaded in these 2 positions when loading the entire holder prior to closing the specimen chamber.

The two detector segments, left (A) and right (B) can be switched independently, enabling the possibility of Brightfield contrast mode (positions 2,3,4,6,7,8), or Darkfield contrast mode (positions 1D and 5D). Operation is fully integrated in the main software.

The STEM detector uses slowscan rates for normal imaging.

Materials or hard samples should also be prepared as for the TEM by Ion beam thinning techniques.

FIGURE 5-16 THE STEM DETECTOR



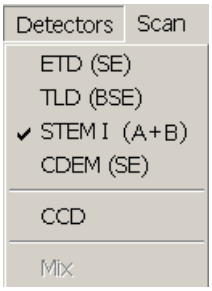
Sample Grid positions for BF/DF

By loading the Stem holder with a sample (tem grid) in one of the appropriate positions provided, Brightfield and or Darkfield imaging can be achieved. The following table refers to the numbering of the positions and their related capabilities.

TABLE 5-9 STEM DETECTOR POSITIONS

Grid Position	Observation and Diode switching
6,7,8	Brightfield observation - use A segment switch only.
2,3,4	Brightfield observation - use B segment switch only.
D1 and D5	Darkfield/Brightfield observation - If the object for observation is left of the segment separator then A switching will give Brightfield and B switching will give Darkfield observation. The opposite applies if the object is right of the segment separator.

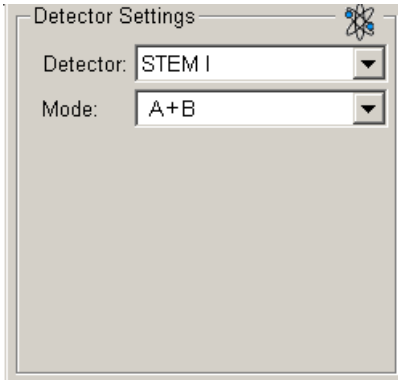
User interface



The STEM detector like other detectors is selectable from the Detector menu within the xTUI. The mode function can be chosen from the Detector Page. The A+B condition (default) is used first setup so that the total detector is working. To switch BF/DF choose A or B from the dropdown list. This will switch either side of the detector diode.

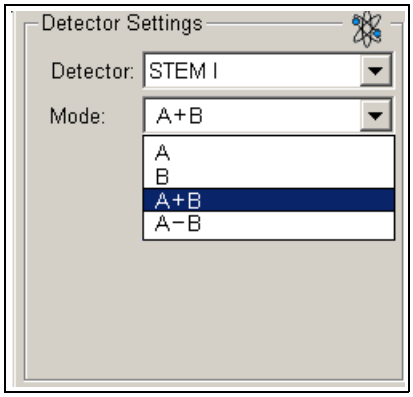
The Left segment represents the positions 6,7 and 8 and therefore to activate switch A diode.

The Right segment represents the positions 2,3 and 4 and therefore to activate switch B diode.



Choosing A-B from the dropdown list will give a negative image that although will not be used frequently may highlight features by contrast not otherwise easily seen.

FIGURE 5-17 STEM DETECTOR CHOICES



Loading samples

The STEM holder part of the detector can either be loaded with samples while outside the SEM or when it is mounted and fixed to the stage movement.

It is more convenient to load the holder before attaching to the stage.

The central screw on the top of the holder can be loosened and the top removed. This exposes the 8 grid positions as recessed round holes

with tweezers slots on the base plate. Positions 2, 3, 4, 6, 7 and 8 will provide only Brightfield imaging whereas positions D1 and D5 will give both Brightfield and Darkfield imaging. Load the TEM Grids (samples) sample face-up in the grid holes. The holder top has raised rings to press down in the grid holes to hold the TEM grids firmly in place. The numbers on the top should overlay the same numbers on the base plate when replacing the holder top. Replace the holder top carefully and tighten down the central screw. The detector and sample holder is now primed for use.

The removal of sample grids is in the reverse order.

Free Working Distance position.

When vacuum is obtained in the system switch on the high voltage for the electron column at 20kV, spot 3. Using a fast scan focus on the top of the STEM holder surface with the SE detector. Click on the Z<>FWD button on the Tool bar and bring the focused surface to 5 mm FWD by changing the Z value on the Stage Control Page. Move to the appropriate sample position and refocus on the grid bars of the TEM grid. The FWD and Z position has now lengthened and re-selection of 5 mm in the Z value on the Stage Control Page is necessary. This procedure is necessary to prevent inadvertently bringing the detector in contact with the final lens. The minimum safe distance to the sample surface for FWD is 3 mm, be aware that the holder surface is now closer to the lens than the sample.

By moving off the grid bars and fine focusing on the sample most correction of image rotation and astigmatism can be performed in the SE or TLD Mode 1. Move to Mode 2 to obtain high resolution imaging, perhaps with further correction of astigmatism.

Obtaining a Brightfield (BF) image.

The STEM detector like the BSE detector is solid state it must be operated at slow scan rates for the best imaging.

Choose the STEM detector from the Detector Menu and select the correct diode operation, from the Detector Page, depending on the sample position in the holder. An image should be visible of the transmission sample at low magnification.

Change the kV to suit the contrast necessary through the sample. For example light element materials such as poly-silicon or silicon oxide samples which may work better with 5 - 10 kV to create contrast, whereas dense materials such as metals may require 10 - 20 kV or higher. Finally increase the magnification to that required, fine focus and stigmate the image.

If either lens alignment or aperture adjustment is required, temporarily switching to ETD or TLD mode is recommended. Adjustment using secondary electron detection is easier because fast scan speeds can be used.

Obtaining a Darkfield (DF) image.

The samples that reside in the D1 and D5 positions can be observed in Darkfield mode.

The separator line of the two diodes crosses vertically the positions of D1 and D5 so that an area of interest on the left side of the line can be observed with the right-hand diode for Darkfield and with the left-

hand diode for Brightfield observation. The opposite is true for sample on the right side of the line.

Dark Field observation may require higher kV to create a suitable image as the angle subtended to the detection diode can be wide. Choosing 2x the value used for Brightfield is a good guide level.

EDX analysis with STEM.

If the Nova has a EDX system attached, operate this in Mode 3 using the TLD detector mode for reference only, but back to the STEM detector in Bright Field mode for EDX analysis.

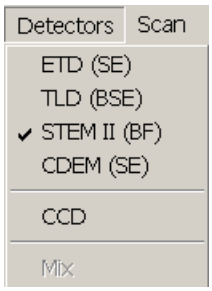
Set the sample surface to 5 mm FWD.

Select the area of interest in the STEM mode and perform X-ray analysis, Mapping or Linescans as appropriate.

Because the samples are not bulk in nature the beam spread normally associated with SEM samples will be greatly reduced and therefore higher spatial resolution can be obtained in the STEM mode. This also provides less background in the spectrum and allows better separation of peaks as well as more accurate lower count rate mapping.

The kV chosen for analysis will still depend mainly on the composition of the sample.

Retractable STEM 2 detector (Option)



The STEM 2 detector is permanently mounted in the chamber and is retracted when not in use. This is controlled from the Stage control page by clicking on the Insert/Retract button. The STEM 2 detector is only used with the E-column operation in Mode 1, 2 or 3.

When the Flip-stage is selected, and the stage tilt (T) is at 0°, the STEM detector can be inserted. To avoid damaging the detector, it is forbidden to insert while the stage is tilted, or the bulk stage is selected. After positioning the sample of interest with the Stage, and changing the flip angle (AF) to 90°, STEM imaging can begin.

The STEM detector is a solid-state design with 14 independent regions. Each segment can be independently selected in the xT software, allowing imaging in the following modes by differing collection angle:

- Bright Field (BF)
- Dark Field (DF)
- High Angle Annular Dark Field (HAADF)
- Partial HADF segments (HADF1)
- Complimentary HADF segments (HADF2)

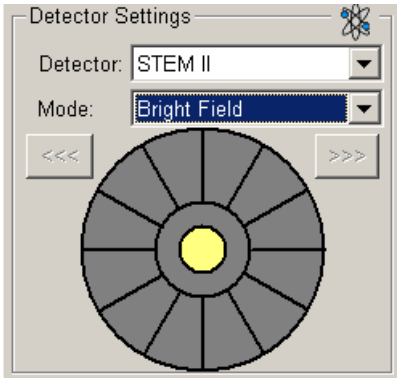
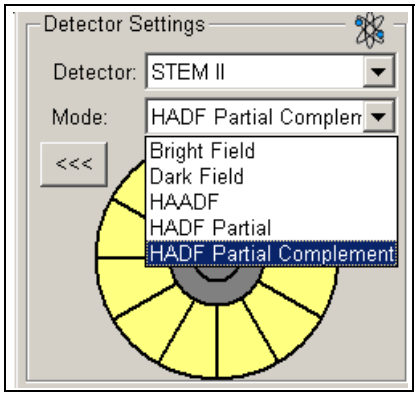
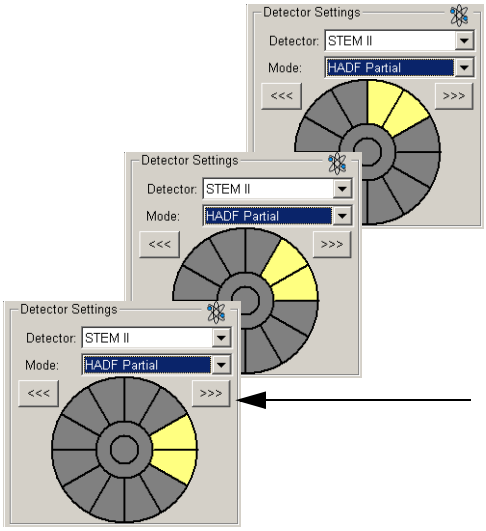


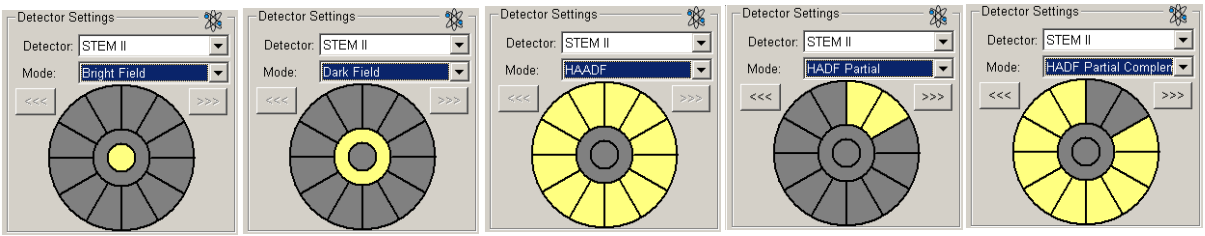
FIGURE 5-18 STEM DETECTOR CHOICES.





When a mode is selected from the dropdown list it updates on the Detector Page graphic and on the Detector Menu. When BF, DF and HAADF imaging is selected the graphic is fixed and cannot be changed, but when HADF1 or HADF2 are selected, the graphic can be manipulated by clicking segments on or off. In modes HADF 1 or 2 the position of ON segments (1 to 11) can be rotated via the arrow buttons either clockwise or anti-clockwise.

A combination of segments can be selected in HADF1 to determine the best signal from a specific sample, or region of interest within a sample. Subsequent selection of HADF2 selects the complement of HADF1. The following possibilities are shown below:



Optimizing the Image

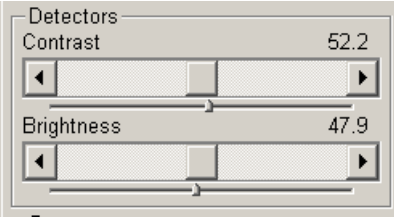
Improve the image by changing scan speeds, contrast/brightness, focusing, stigmating, adjusting beam current, or magnification.

Changing Scan Speeds

To produce the highest quality image at low beam currents, use slow scan rates.

If an image is noisy with No Averaging selected, changing the scan speed to a slower scan improves the image quality by increasing the signal-to-noise ratio. You can also improve image quality by using Averaging.

Contrast and Brightness



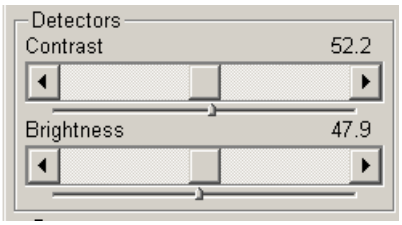
This Detector module contains 2 logarithmic and 2 linear adjusters which allow you to change contrast and brightness by clicking and dragging the middle slider on the large bar, or the same on the pointer in the small bar. The functionality is as follows:

TABLE 5-10 C & B OPERATION

Item	Function
middle slider	For large or small adjustments, depending where you release it. The further from the centre that the middle slider is pulled, the larger the change. This is Logarithmic.
gray bar	For larger adjustments, single step increments.
end arrow	For finer adjustments, single step increments.
small slider	For Linear adjustment, continuous.

These adjusters always have a label in the upper left and value in the right corner as a readout value.

Correcting Contrast and Brightness

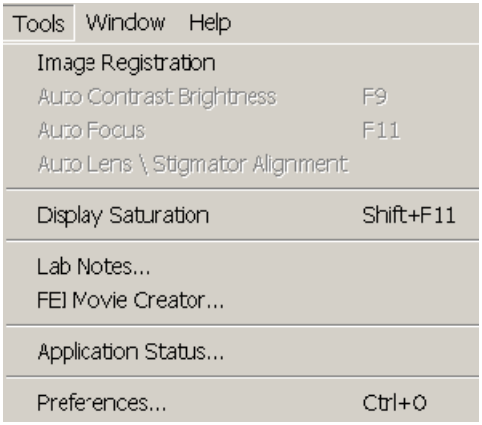


The contrast and brightness settings can be set manually either by using the MUI or by adjusting the CONTRAST and BRIGHTNESS controls in the DETECTOR module found on several pages. The following description will work for both methods.

TABLE 5-11 CORRECTING C & B

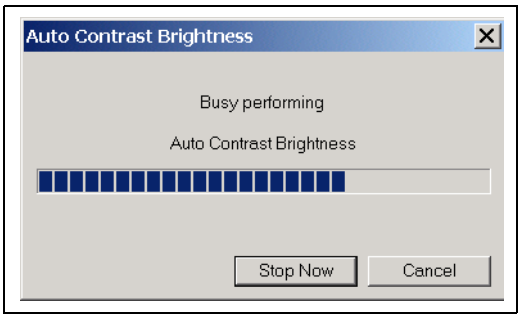
Step	Action
1	Select a medium speed scan in an active Quad
2	Reduce the contrast to zero and adjust the brightness to a level so that the last gray level can be seen, by eye, before the screen goes black.
3	Increase the contrast so that the signal level shows an image.
4	If necessary, adjust the brightness level to improve the image.

Auto Contrast and Brightness



Auto Contrast and Brightness can be activated by pressing the Auto C&B icon button on the Tool bar or the item in the Tools menu. The system will attempt a correcting of the contrast and brightness levels to suit the sample so that the majority of graylevels are displayed. When activated the following dialog appears to show the progress of the function. It can also be activated by pressing function key **F9**.

FIGURE 5-19 ACB DIALOG BOX



The function can be interrupted by clicking on the STOP NOW button. This will leave the image at the stage of progress at stopping. clicking CANCEL before the function ends will return the image back to it's original status.

Correcting Focus

The easiest way to focus is to find a feature of interest on a sample with distinct edges. Use a combination of contrast, brightness, magnification, and stigmation adjustments to maximize the image quality.

To avoid scanning too long with the ion beam and milling away the sample before you take the final image, move away from the feature of interest with the X and Y stage controls, and focus until the image is sharp on a adjacent area.

Focusing at 2 X to 3 X the magnification needed for the final result makes the lower magnification sharper. For example, for high resolution output, set the magnification level at 2000 X and focus at 4000 X to 8000 X.

Focusing with the MUI

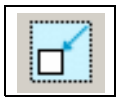
You can also use the MUI COARSE and FINE focus knobs to focus the image. The image immediately responds to the MUI without a cursor on-screen.

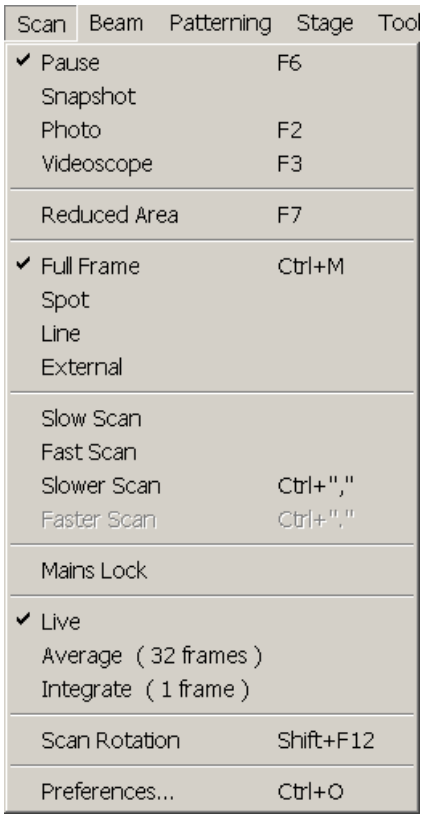
Focusing with the Mouse

Press CRTL right-click simultaneously while moving the mouse from side to side to focus the image, then release.

TABLE 5-12 CORRECTING FOCUS WITH THE MOUSE

Step	Action
1	Hold down the right mouse button while the cursor is in the active Quad
2	The focus cursor, which is a double ended arrow will appear. Move the focus cursor from side to side until the image is sharp.
3	When engaged, the focus cursor is active over the whole screen but will not interfere with other controls
4	Move the specimen to a desired area with the X and Y stage controls and refocus until the image is sharp.
5	If this is the first time focusing the new specimen then click on the Z to FWD icon button on the Tool Bar to confirm focal distance to the Z value on the NAVIGATION page.





Using Reduced area for Focus

When Reduced area is chosen, the small green area frame appears in the middle of the screen. This can be used as a Focus aid as the scan speed is faster in the smaller area. It can be activated from the SCAN menu, the REDUCED AREA button on the Tool bar, or by **F7**. The first time after defaulting of the program it will appear in the center of the Quad or Screen, after setting to preference it will pop-up where it last resided.

Moving the Reduced Area

Click and hold the left mouse button in the selected area. The cursor changes to a 4 ended arrow. This will take time, depending on the actual scan speed. Now drag the selected area to the desired position and release the mouse button.

Changing the Size of the Reduced Area

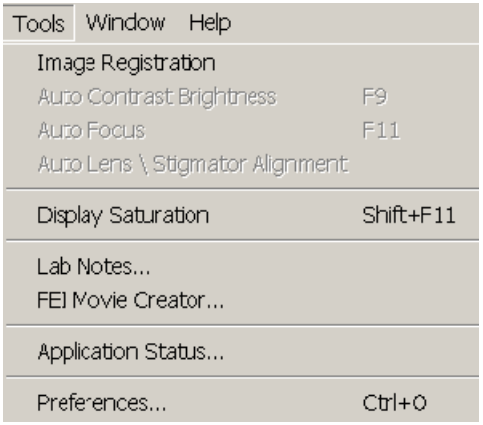
Click and hold the left mouse button at the edge of the selected area. The cursor changes to a 2 ended arrow, either horizontal or vertical. Now drag the selected area out or in to the desired size and release the mouse button.

Making a new Reduced Area

Place the cursor outside of the selected area and make sure Get or Shift are not activated. The cursor should be the normal arrow symbol. Move the cursor to where you want the left upper corner of the selected area to be. Click the left mouse button and drag the cursor until the rectangle onscreen includes the area you want to select. Release the left mouse button.

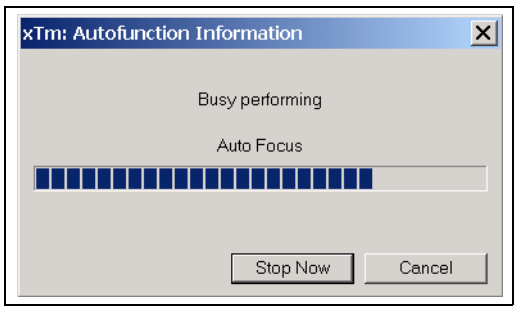
When the Reduced area frame is being manipulated it turns yellow until released, then it reverts to green.

Auto Focus



Auto Focus can be activated by pressing the Auto focus icon button on the Tool bar or the item in the Tools menu. The system will attempt to correct the focus independent of the working distance or focus set. When activated the following dialogue appears to show the progress of the function. The function can be interrupted by clicking on the STOP NOW button. This will leave the image at the stage of progress at stopping. Clicking CANCEL before the function ends will return the image back to it's original status.

FIGURE 5-20 AUTO FOCUS DIALOGUE BOX



Correcting Astigmatism

Stigmating with the Mouse

It is necessary to correct astigmatism of the image (also known as "stigmate") when you change apertures, samples or working distance. Astigmatism in the image is usually only visible at higher magnifications (3000X or more). If astigmatism is present, the result is a directional distortion change of 90° between the two out-of-focus conditions.

TABLE 5-13 MOUSE CORRECTED ASTIGMATISM

Step	Action
1	Focus the image as well as possible using the mouse.
2	Bring the image just slightly out of focus in one direction to see any astigmatic distortion.
3	Defocus in the other direction to observe a different astigmatic distortion.
4	Bring the focus to the midpoint between the two distortions.
5	Press shift and the right mouse button down while in the active Quad. This will result in a 4 arrowed cross appearing on the screen with the cursor position at its center. Still holding the right mouse button down, move the center of the cross around the screen to achieve astigmatism correction (when the image is at its sharpest).
6	When you are satisfied with the image, release the right mouse button.
7	If astigmatism is severe and the cross is close to the edge of the screen when nearing correction, release the right mouse button, and reposition the cross in the center of the screen. Then repeat the procedure above to perform further astigmatism correction.

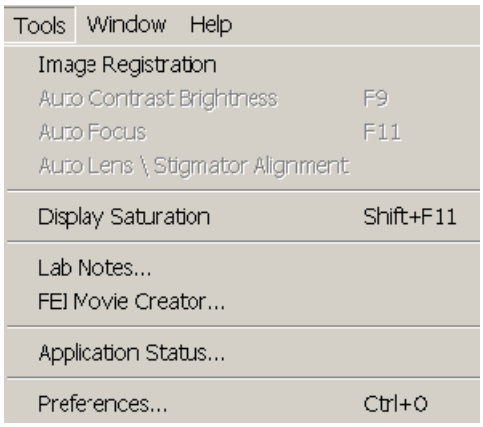
Stigmating with the MUI

The following describes how you can stigmate with the MUI.

TABLE 5-14 STIGMATING WITH THE MUI

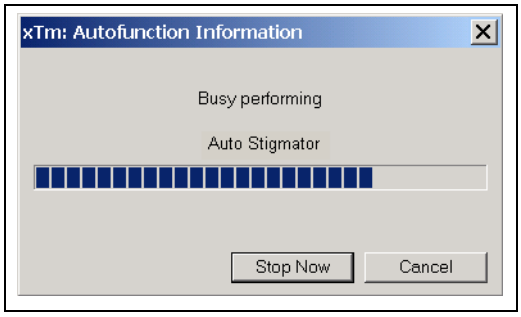
Step	Action
1	Using the MUI FOCUS knobs, bring the image just slightly out of focus in one direction to see any astigmatic distortion.
2	Defocus in the other direction to observe a different astigmatic distortion.
3	Bring the focus to the midpoint between the two distortions.
4	Adjust image sharpness with the stigmator X and Y knobs until the best image is achieved. *The computer beeps when the stigmation limits are reached.*
5	Repeat steps 1-4 as necessary.

Auto Lens \ Stigmator Alignment

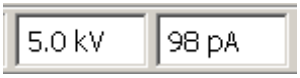


The Auto Lens \ Stig Alignment is a combination of an auto lens align and auto stigmator. This can be activated by clicking **Auto Lens \ Stigmator Alignment** in the Tools menu. The system will attempt to correct the stigmator independent of the working distance or focus set. When activated the following dialogue appears to show the progress of the function. The function can be interrupted by clicking on the STOP NOW button. This will leave the image at the stage of progress at stopping. clicking CANCEL before the function ends will return the image back to it's original status.

FIGURE 5-21 AUTO STIGMATOR DIALOGUE BOX



Selecting Beam Conditions

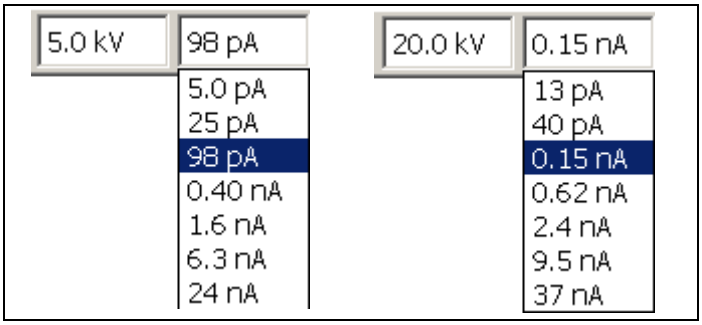


High Voltage and Beam Current

The choice of High Voltage and Beam Current display in the editable dropdown list boxes on the Tool Bar will depend on the type of beam that is active, either Electron or Ion.

The High Voltage and Beam Current are related in that any selected HV will provide an individual set of beam current values for that HV. Changing HV will change the beam current values to suit. Both the Electron and Ion beam have calculated values of beam current related to the HV values. The examples given here show two set conditions of HV selected and the same beam current, but the accending values have changed to suit the selected HV in each case.

FIGURE 5-22 HV RELATED BEAM CURRENT VALUES



For each ascending high voltage, the range of beam currents increases in value accordingly. When the aperture for the Electron column is changed this also influences the calculated range of beam currents for all HV's. Likewise for the Ion column apertures.

Changing High Voltage

Click on the text box and the list of voltages will be available. Click on the required voltage and it will appear in the text box. The dropdown list will automatically close. This can be done while the beam for the column is on, in which case the change will be immediate.

Default values can be set in the list box from the Preferences dialog tab labelled BEAM. Any other HV value can be set with the use of the High Voltage slider placed in the Beam page.

Changing Beam Current

Click on the dropdown arrow to the right of the text box and the list of currents will be available. Click on the required current and it will appear in the text box. The dropdown list will automatically close. This can be done while the beam for the column is on, in which case the change will be immediate.

For the Electron beam, deciding which beam current is correct for a particular magnification can be determined when you achieve good focus and astigmatism correction easily at the chosen magnification.

Choosing the correct beam current for Ion beam use is determined by the application.

E-Beam Aperture Strip

The E-Beam Aperture strip contains five sized heated apertures, with steps between each hole in the X direction. The following table gives the factory default five aperture sizes and their suggested uses

TABLE 5-15 DEFAULT FACTORY APERTURE SIZES

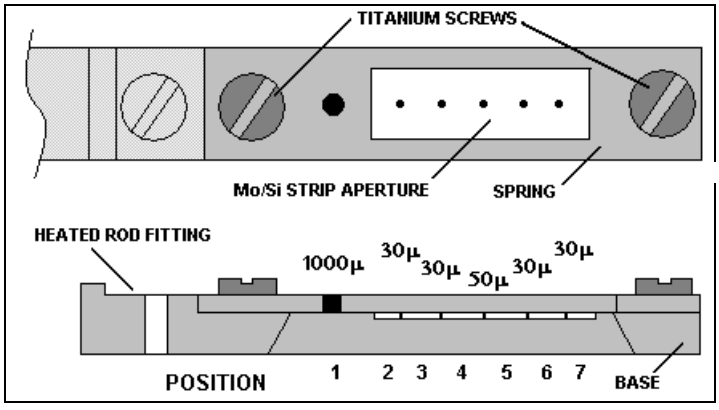
Aperture	Use
100µm (Preset 1)	High beam current applications
50µm (Preset 2)	X-ray dot maps
40 µm (Preset 3)	X-ray mapping of low-Z elements at low kV
30 µm (Preset 4)	For general use and high resolution imaging
30µm (Preset 5)	For general use and high resolution imaging

Aperture Loading Guidelines

The aperture holder rod is heated while in operation to keep the apertures in a clean state. In addition the aperture strip is mounted within a module that can be attached to the rod by a single screw.The aperture strip and module is supplied as a complete unit for ease of mounting. The aperture strips come in two types:

- 5 hole 30, 30, 50, 30, 30 µm
- 5 hole 30, 30, 40, 50, 100 µm (factory default)

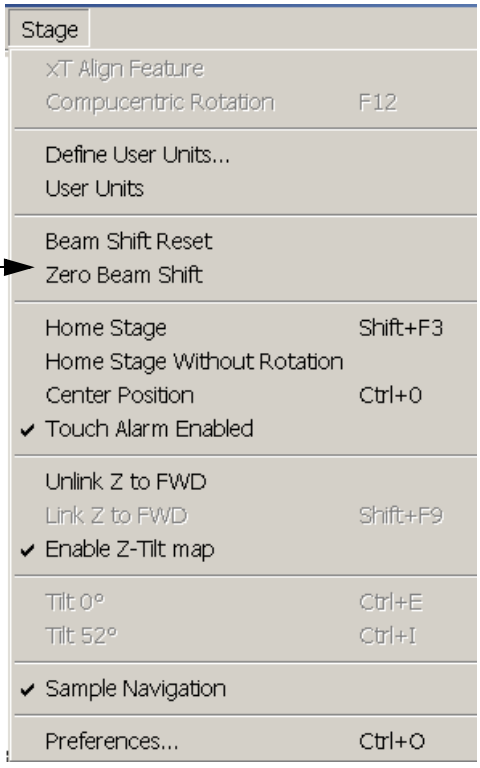
FIGURE 5-23 THE HEATED APERTURE HOLDER MODULE

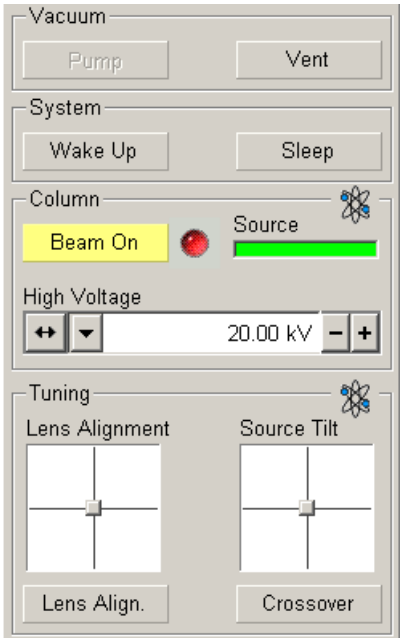


Selecting E-Beam Apertures

Users can select a different aperture by turning the mechanical aperture control on the SEM column to the preset position number required. It has a click-stop mechanism.This ranges from 1 to 5 for apertures, where as positions 6 and 7 are blank. This procedure should only be attempted when the system is not being used for milling.

Whenever a different aperture is selected it is recommended to use Mode 1 30 kV spot 3, with the specimen at a 5 mm working distance. After selecting a different aperture mechanically the correct software tables has to be set for the selected aperture. This can be done from the menu **Beam / SEM Aperture**.





Strip Aperture Alignment Procedure

Before you align the column, be sure that the final lens aperture is correctly aligned. If the final lens aperture has to be aligned, choose the smallest for the best results. It is recommended to use 30 kV and spot 3, Mode 1, with the specimen at a 5 mm working distance, the eucentric working distance in the xT FIB/SEM.

When the aperture is well aligned, the image does not rotate at low magnification or move at high magnification during focusing. The position of the final aperture should remain constant and should not be changed further during the alignment procedures.

TABLE 5-16 ALIGNING THE FINAL LENS APERTURE

Step	Action
1	Go to **Mode 1** at 5 mm WD. Select **Zero Beam Shift** from the **Stage** menu and zero **Lens Alignment** on the **Beam Control** page.
2	Make an image at a magnification of about 10,000X. Select a fast scan rate from the Scan Speed control and Average 4 from the **Filter** control on the **Tool bar**.
3	Move the stage to find a good area of interest, and focus as best one can.
4	center a feature with the Get function.
5	Click in the **Lens Align** check box in the **Tuning** module of the **Beam Control** page, a cross appears in the center of the screen and the image rotates about a point on the screen. Adjust the position using two mechanical aperture knobs so that the center of the rotation is over the cross.
6	Increase the magnification to 20 000x and realign. If necessary, repeat at 40 000x. At higher magnification the image may move very slightly in a certain direction.

TABLE 5-16 ALIGNING THE FINAL LENS APERTURE

Step	Action
7	When corrected, switch off the **Modulator**. There should be no image shift when the focus control is used in either **Mode 1** or **Mode 2**.
8	Finally, open the **Beam** menu and click on the same aperture value from the **SEM Aperture** sub-menu.

I-Beam Apertures

In general, use a smaller aperture for high resolution and a larger one for large scale or faster milling.

Optimal I-Beam Currents

Use the following suggestions for choosing optimal I-Beam currents:

TABLE 5-17 GENERAL OPTIMAL I-BEAM CURRENTS

Beam Current	Best Use
1-10 pA	High resolution
30-50 pA	Standard imaging
>100 pA	Milling

For more specific applications, see the table below.

TABLE 5-18 SPECIFIC OPTIMAL I-BEAM CURRENTS

Beam Current	Best Use
1 pA	• Very high-resolution imaging • High aspect ratio holes • High-resolution imaging • Pt via filling
10 pA	• Quick imaging • Fast Pt via filling
30, 50 pA	• Navigation imaging • Milling submicron holes • Final milling on cross sections
100 pA	• Milling micron-sized holes • Intermediate/final milling on cross sections • Short Pt strap deposition

TABLE 5-18 SPECIFIC OPTIMAL I-BEAM CURRENTS

Beam Current	Best Use
300, 500 pA	• Milling micron sized holes • Medium Pt strap deposition • Intermediate milling on cross sections
1000 pA	• Initial milling for small cross sections • Long Pt strap deposition
3000 pA	• Initial milling for medium cross sections • Longer Pt strap deposition
5000 pA - 7000 pA	• Initial milling for medium-large cross sections • Pt probe pad deposition (40 µm x 40 µm)
11500 pA - 20 nA	• Initial milling for large cross sections • Pt bond pad deposition (50 µm x 50 µm)

I-Beam Aperture Alignment

For a complete alignment procedure for Ion beam apertures refer to Alignment 210 in the section ‘Ion Beam Alignment’ of chapter 9.

Working with magnification

Principle

Magnification is the ratio of the viewing area on the monitor screen to the scanned area on the sample.

FIGURE 5-24 MAGNIFICATION PRINCIPLE.

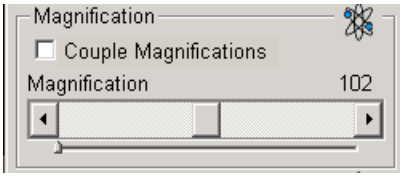
$$MAGNIFICATION = \frac{Viewed\ Area}{Scanned\ Area}$$

If the size of the raster on the sample is made smaller while the raster on the monitor remains constant in size, the magnification of the image increases. At low magnification, you will see a large field of view. At medium magnification, you see a portion of the original scanned area. At high magnification, you are zoomed in on only a small portion of the original total scanned area.

Changing Magnification

Use the Magnification settings from the dropdown list to select from predefined values. If the current value is in the list, it is indicated with a coloured background. Click on the text box and the list of magnifications will be available. Click on the required magnification and it will appear in the text box. The dropdown list will automatically close. This can be done while the beam for the column is on, in which case the change will be immediate. A magnification value can be entered into the text box and this will replace the nearest magnification value in the list by pressing the keyboard ENTER key. It will also become the current magnification value.

Magnification



The Magnification module gives access to coupling the magnification of both beams at a particular magnification. The magnification is set with the slider and then locked by ticking the box labelled COUPLE MAGNIFICATIONS. The Icon logo for the beam in active operation is displayed at the right side of the module.This feature can also be accessed via the Beam menu as **Couple Magnification**.

Keypad +/- keys

Magnification can also be changed with the Keypad +/- keys. The Plus button (+) increases the magnification 2x, and the Minus (-) button decrease the magnification 0.5x.

Selecting a different magnification results in a change of magnification on the screen during live imaging.

Using the Mouse Wheel

Alternatively, the mouse wheel can be used for changing magnification. Moving the wheel up decreases the magnification and moving the wheel down increases the magnification. Coarse and fine control can be operated with Ctrl or Shift keys from the keyboard.

TABLE 5-19 USING MOUSE WHEEL MAGNIFICATION

Key	Function
Wheel up + Ctrl	Decreases magnification. Coarse control
Wheel up + Shift	Decreases magnification. Fine control
Wheel down + Ctrl	Increases magnification. Coarse control
Wheel down+Shift	Increases magnification. Fine control

Magnification Normalised

The Star (*****) key on the Keypad can be use to round off the magnification value before storing the image in case the value is odd e.g. 10,063x would become 10,000. The condition also takes into account the image size by zooming and the micron bar scaling.

Choosing a Final Lens Mode

The following 3 Final Lens modes are used by the E-column final lens to be optimized for different tasks. Use the Tool Bar buttons or the SEM Mode in the Beam Menu to switch between modes.

Mode 1

This is the default survey mode. This mode is essentially for navigating and reviewing sites at lower magnifications. In Mode 1 the immersion lens is switched off and the default detector is the ETD in Secondary Electron operation.

Mode 2

Mode 2 is used for most imaging operations at magnifications greater than 2,000 x. In this mode the immersion lens is switched on, and the default detector is the TLD in Secondary Electron operation. This mode is used to form ultra-high resolution electron images of the sample.

If I-Beam imaging is selected in Mode 2, the final lens is switched off to allow I-Beam imaging to take place with the last selected I-Beam detector.

Selecting Mode 2 also has it’s own Beam menu presets.

Mode 3

Mode 3 is used for analytical work such as EDX where the Immersion Lens is not so powerful as Mode 2 but can act as a electron trap to improve X-ray collection. This mode can be used with the I or E Beam. Selecting Mode 3 also has it’s own Beam menu presets.

Taking a Snapshot

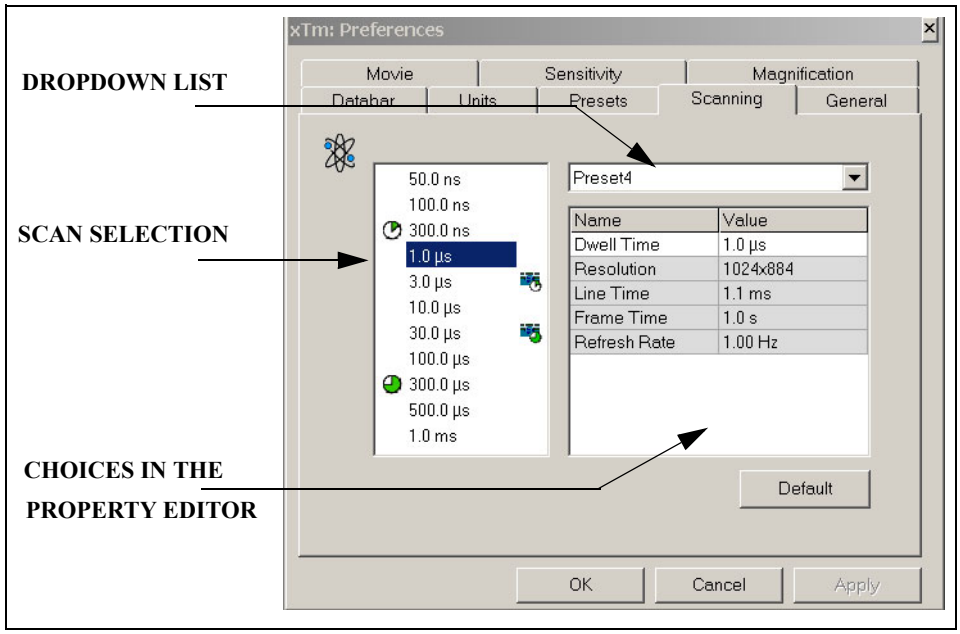
Snapshot Setup

The Snapshot Tool Bar button is provided to take a fast snapshot of the milled position during a milling process.

The result will depend on the setup in Preferences/Scanning. This involves selecting several parameters, such as Dwell Time and Resolution. These can be selected from the property editor once the snapshot icon either from the list above, or from the graphical list on the left has been chosen.

If the properties are not to be changed, only dwell time, then the Snapshot icon in the graphical area can be dragged to a new value of Dwell Time with the left mouse button. Once released the new values update in the property editor.

FIGURE 5-25 SNAPSHOT SETUP



To set-up Snapshot Preference for E and I beams

- Make the destination of the to-be-saved files available to the save routine in the **File** menu, by opening a folder and saving a test file to it.
- Open the Preferences for Scanning. Select the **Snapshot** scan preset from the dropdown list at the top of property editor.
- Select a suitable dwell time from the Scan Selection in Scan Preferences by dragging the Snapshot camera icon to the required value, or by selecting from the DWELL TIME property editor of the Scan Presets.
- Select a pixel resolution from the RESOLUTION property editor of the Scan Presets.
- Enter the number of frames in the INTEGRATE property editor of the Scan Presets.

- Select the ACTION property for either Save, Save As or None.

  Save - Prompts the Save dialog and displays the next increment with the last set-up or used folder location.

  Save As... - Prompts the Save As... dialog for the user to choose the file name and location.

  None - No save function just a screen image.

How to Use Snapshot

The **Snapshot** icon button is represented as a camera (with a short time dial) on the **Tool Bar**. When an image is required at any time one can click on **Snapshot** and a single scan (preset scan setting) will be activated which pauses at the end of the scan time. The result can be just for viewing to check against the patterning condition, or for saving on the harddrive.

Saving can be automatic to a predetermined file location using the next available label/number or user defined.

TABLE 5-20 USING SNAPSHOT FOR IMAGE CAPTURE

Step	Action
1	Select a quad to make a snapshot with the beam which is selected in that quad (during fib-milling: select e-quad and then hit snapshot).
2	Click on the Snapshot button on the Tool Bar. The beam will start to scan the area.
3	The scan will make the snapshot scan or scans (filtered) and pause.
4	If Save is the ACTION then the image is saved to a predetermined directory on the hard drive. If Save As… is the ACTION then the Save As… dialog will prompt the user for a destination on the hard drive. With 'None' selected in ACTION the activity will stop at point 3.
5	After the image is saved the scan can be released by clicking once on the Pause/Start Scanning button on the Tool Bar.

Taking a Photo

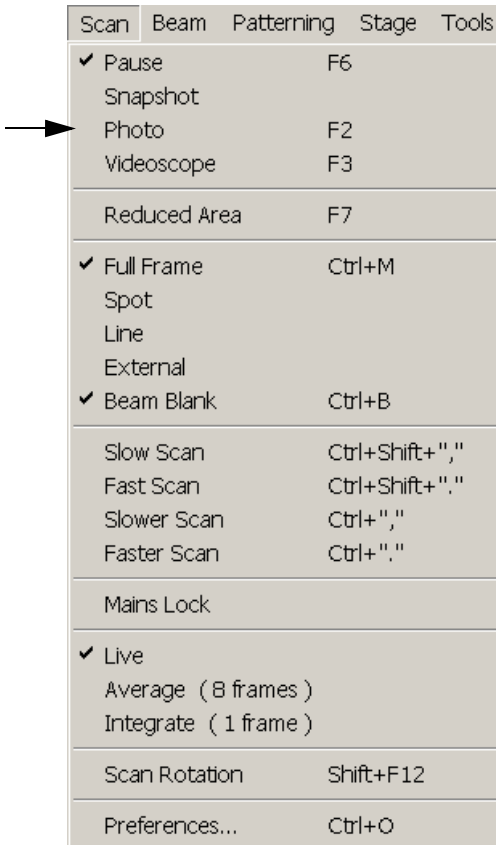


Photo Setup

This facility, like Snapshot, can also be preset in Preferences/ Scanning. Slower scan rates will be most generally used with this image capture method.

To Set-up Photo for I and E beams

- Make the destination of the to-be-saved files available to the Save routine in the File menu, by opening a folder and saving a test file to it.
- Open the Preferences for Scanning. Select the **Photo** scan preset from the dropdown list at the top of property editor.

Make adjustment to the Property Editors:

- Select a suitable long dwell time from the Scan Selection in Scan Preferences by dragging the Photo camera icon to the required value, or by selecting from the DWELL TIME property editor of the Scan Presets.
- Select a high pixel resolution from the RESOLUTION property editor of the Scan Presets.
- Select the ACTION property for either Save or Save As.

  Save - Prompts the Save dialog and displays the next increment with the last set-up or used folder location.

  Save As... - Prompts the Save As... dialog for the user to choose the file name and location.

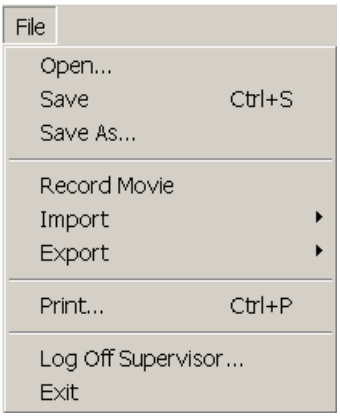
How to use Photo

Clicking once on the PHOTO item in the **Scan** menu, or pressing **F2** on the keyboard will allow a preset high quality, high resolution image to be taken.

TABLE 5-21 USING PHOTO FOR IMAGE CAPTURE

Step	Action
1	Set the required Magnification.
2	Increase the magnification at least 2x. Focus and Stigmate using the reduced area. Return the magnification and scan to their original settings.
3	Set Contrast and Brightness correct.
4	Click once on PHOTO in the **Scan** menu or **F2** to take an image.
5	The image will now be saved via Save or Save As...
6	Click on **Pause/Start Scanning** button on the **Tool Bar** to start scanning.

Single Images Saving / Opening



Save

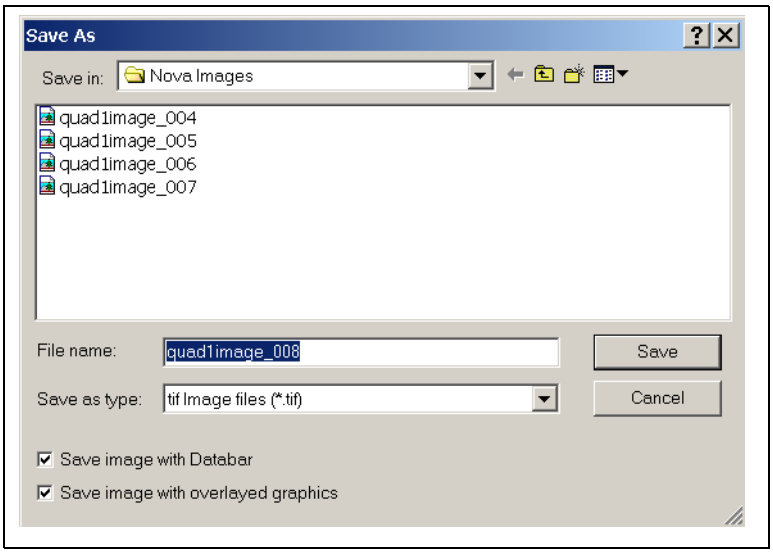
The **Save** function can be used to save and update to the original stored image and therefore is a direct command without confirmation if the label remains the same. This is usually require for a restored image from the archive. Click on **Save** in the **File menu** and the file will be saved automatically to it's existing label and the original file will be overwritten. The function also operates by clicking on the **Ctrl** and the **S** key.

The Save method is also employed in the Snapshot/Photo function under Archive Option but the image capture routine increments the label and therefore adds to the listed images instead of overwriting the last image.The image is given the last known label including a number that is incremental with successive images, i.e. Label_001.tif, Label_002.tif, etc.

Save As...

Clicking on **Save As**, with the left mouse button, opens a dialog for saving an image, which provides an opportunity to change the file name and location. The Save As...method is also employed in the Snapshot/Photo function under Archive Option but the image capture routine prompts the Save As... dialog.

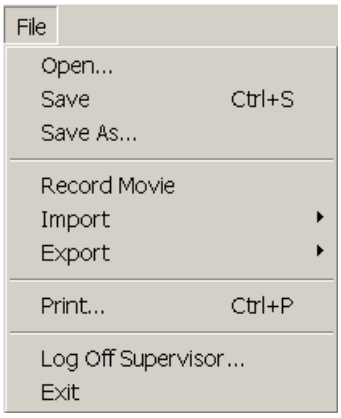
FIGURE 5-26 SAVE AS... DIALOG



The dialogue displays, by default, the location last used to save or open files from xTUI and the name last used in the current Quad. You can choose different location and/or (base of) name, select different image format (**Save as type**), and also choose whether to **Save** the **image with** / without **Databar** and **with** / without **overlayed graphics** by checking / unchecking appropriate check box. The settings is remebered per Quad and used for the subsequent Save actions.

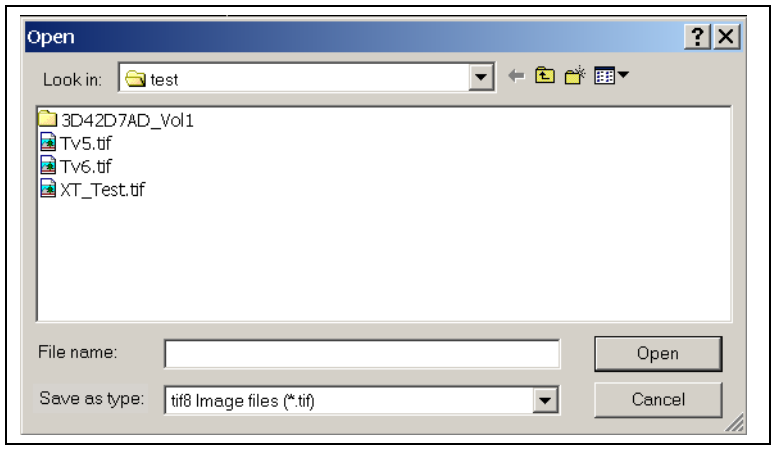
An image can be saved (and opened - see further) in **TIF** (8, 16, and 24 bit colordepth), **JPG** or **BMP** formats. Overlayed graphics can be written into the image either in greyscale (8 or 16 bit) or in color (24 bit).

Open...



Pre-select the quad for the image to open in and then select the image from the Open function. Clicking on **Open...**, with the left mouse button, opens a dialog for opening an image to a particular quad. The dialog displays, by default, the last used location of saved files associated to the imaging function e.g. image file location used by **Snapshot** or **Photo**. After image selection is made clicking on the open button will open the image to the quad that has been selected. Images can be opened in any combination of quads.

OPEN... DIALOG



Movie (multiple image capture)

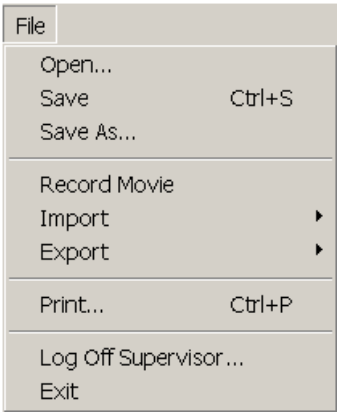


Image capture with Movie

This feature provides the of making digital video files (AVI) for dynamic experiments performed within the microscope.

Up to 3 quads can be recorded at the same time with synchronized start and the possibility to switch between quad and full screen while the video is recording. Movie has the following embedded features:

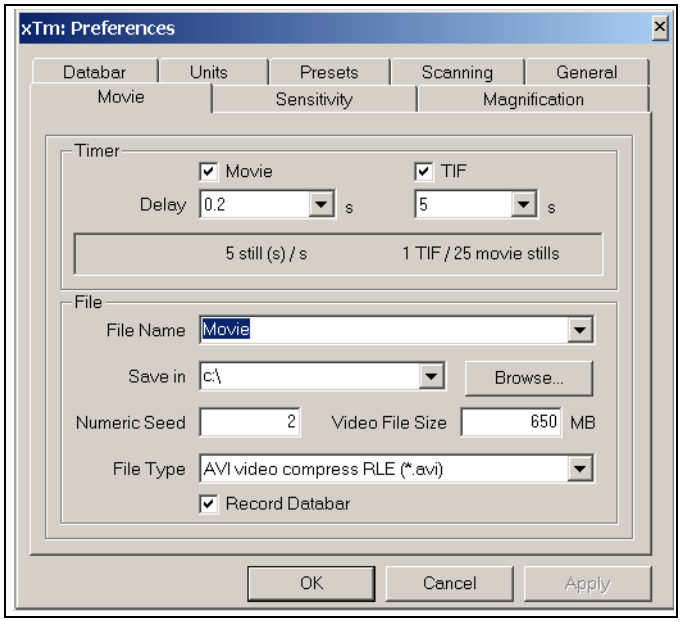
- Resolution at 512 x 422 or 1024 x 884
- Databar image optionally included in the video
- Average or Integration changeable during recording
- Scan speed changeable during recording
- Reduced area pauses Quad for focus or C and B change
- Time remaining indicator
- Single frame Tif images recordable during video sequence
- File format compressed AVI (*.avi)
- Start, Stop and Pause onscreen indicators
- Preferences set-up dialogue

The Preferences Dialogue

The **Preferences** dialogue can be found at the end of some of the menus. The Preferences dialogue consists of tabbed sections. By clicking on the required tab a section will open to allow changes and presetting of conditions for the function chosen.

The **Movie** tab provides two groups one to choose set-up conditions for timing labelled **Timer**, and the other to set-up save conditions for the resultant movie labelled **File**.

FIGURE 5-27 THE MOVIE TAB DIALOGUE



Timer

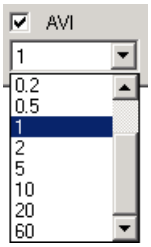
The parameters in this section can be changed when the digital video is inactive, for set-up purposes, but are disabled during the digital video recording.

The digital video is timed asynchronously with the scanning. The recording is controlled by two timers:

1. AVI timer. After video delay time the acquisition buffer of each unpaused quad is stored as a new frame in the video stream. The frame optionally includes image of the databar and a time stamp.

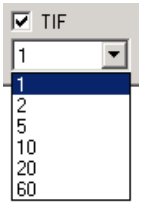
2. TIF timer. After TIF delay time the system will wait until the running scan in unpaused quads is finished and saves a complete image in the TIF format including the databar data for xT Docu. The first image is saved immediately when its scanning is completed.

The Tif delay must be always longer than or equal to the Video delay.



Check box AVI

This is a check box to determine that the movie should be stored. Check it to store the movie at the end of a recording session. The dropdown combo box lists the choice of delay times for the AVI function. These are represented in seconds. Click on a delay time value and it will be highlighted below the check box.



Check box TIF

This is a check box to determine that the Tif files should be stored. Check it to store the Tif files at the end of a recording session. The dropdown combo box lists the choice of delay times for the Tif function. These are represented in seconds. Click on a delay time value and it will be highlighted below the check box.

If the delay time is shorter than what the system can achieve for the current setting, the recording runs as fast as possible.

If both AVI and TIF are recorded, the Tif delay must be longer than or equal to the AVI delay. If this is not true the system reduces the movie delay timing after pressing OK or Apply.

At all times one of these checkboxes remains checked. If the TIF checkbox is unchecked the delay box for TIF is disabled. Equally, if the AVI checkbox is unchecked the delay box for AVI is disabled.

Information field

This read only area is found below the AVI and TIF combo boxes and contains additional information for the user about the number of frames per time unit (seconds, minutes) and further movie data stored to the completed files. This data is calculated from the image resolution valid when the preference dialogue was opened.

File

All parameters in this section can not be changed for the currently running video. Changes made are only valid for the next video recording.

Digital video can be stored in *.avi files from the quads 1 to 3. The video name contains: generic filename, quad name and a numeric seed.

For example: ***myvideo (Quad1) 001. avi***

The filename and the numeric seed are set by the user. The numeric seed is automatically incremented, after the recording has stopped.

Optionally the *.tif files can be stored besides the *.avi. Name of the tif files contains: generic filename, quad name, numeric seed and number of the image in the series.

For example: ***myvideo (Quad2) 003 - 00123.tif.*** The series number has always 5 digits filled by zeros on the left; the first Tif file has number 00001.

File name

Enter here a generic file name valid for the next video recording. A suitable file name must be entered here, if this field is not filled the Movie dialogue can not be closed.

Save in

Enter a suitable path to the directory. If this field is not filled the Movie dialogue can not be closed. If the path is long and cannot be read in the field space the Tool tip can be used to give full information.

Numeric Seed

Enter any number 1 to 999 which is converted to the three digit form with zeros on the left, if necessary.

Video file size

This value specifies the maximal size of video file in MB. Enter a size value lower than 2000 MB. After reaching this size, the video is saved and a recording is started. If this field is not filled the Movie dialogue can not be closed. A dialogue warning appears if there is a Out of Memory condition with the Hard drive.

File type

List box with types of supported digital movie formats. Only compressed formats are used.

Record databar

This checkbox allows the databar to be included in the video when checked. The databar in the video is updated every second.

Movie Procedure

Start, Pause and Stop

The **RED dot** is the start command button that starts the recording of three videos, one for each of the three image quads at the same moment.

If a quad is paused when starting the video, only the first image with a time stamp is stored. When the quad is paused during the video recording, storing of the video frames is interrupted but the video streams keep synchronization for the next unpausing. After reaching the maximal file size, the video is paused, saved and a new video is started with the same name and incremented numeric seed.

When the Red dot, representing 'Start', is pressed it turns to a **Black square**, representing 'Stop'. When pressed the Black square then stops the recording of the video of all three quads and closes the files.

Recording a Movie

The following procedure describes how to set-up and record a movie.

TABLE 5-22 SET-UP AND RECORDING A MOVIE

Step	Action
1	Select **Preferences** at the base of the **Scan** menu. Click on the **Movie** tab. In the **Timer** section check the **AVI** check box and select from the **Delay** time combo box the desired time. Select the **TIF** function by checking the TIF check box if required and select from the TIF combo box the desired time.
2	In the **File** section fill in the **File name** and give the '**Save in**' directory path. Fill in the **Numeric seed** value and the **Video file size**. Select the **File type** and choose whether the Databar need be recorded with the **Record databar** check box. Choose **Apply** to change temporary to the new values or **OK** for permanent fixing of the values entered or **Cancel** to return to the original values at opening of Preferences.
3	Choose which quads will NOT be active during recording by clicking on the quads in turn and pressing the **Pause** button on the button bar. This applies only to quads 1 - 3.

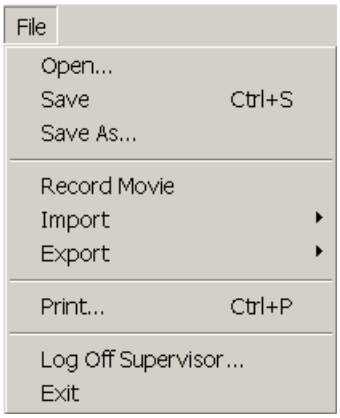
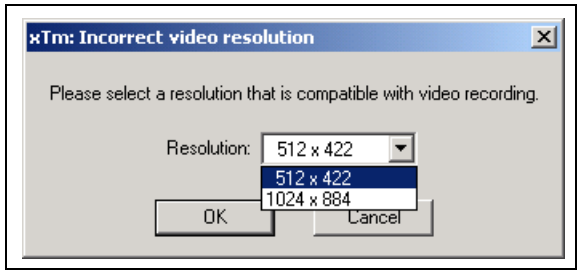


TABLE 5-22 SET-UP AND RECORDING A MOVIE

Step	Action
4	Set up the imaging in the live quad and press the **RED dot** on the button bar or **Record Movie** in the **File** menu.The first frame with a time stamp of all quads is recorded. Next the recording starts and the duration is dependant on the set-up in the Preferences.When the video is started and the scan resolution is higher than 1024 the following dialogue occurs: 
5	Choose either of the resolution values and click on OK. The Movie continues to record at the selected resolution.
6	The Movie will stop when the **Black square** button is pressed on the button bar. The stop command stops recording of the video of up to all three quads and closes the files.

Quad Indicators

A Red dot indicates that recording is active in this quad. It is displayed in the top right hand corner below the timer display.

A Red ball with the Pause symbol indicates that the record is running but the data from this quad is not stored. It is displayed in the top right hand corner below the timer display.

An estimation of the time remaining till the end of the video is displayed in the upper right corner. The time is displayed in the format hh:mm:ss. The time is calculated from the average disk space consumption and the free space on the disk.

FEI Movie Creator

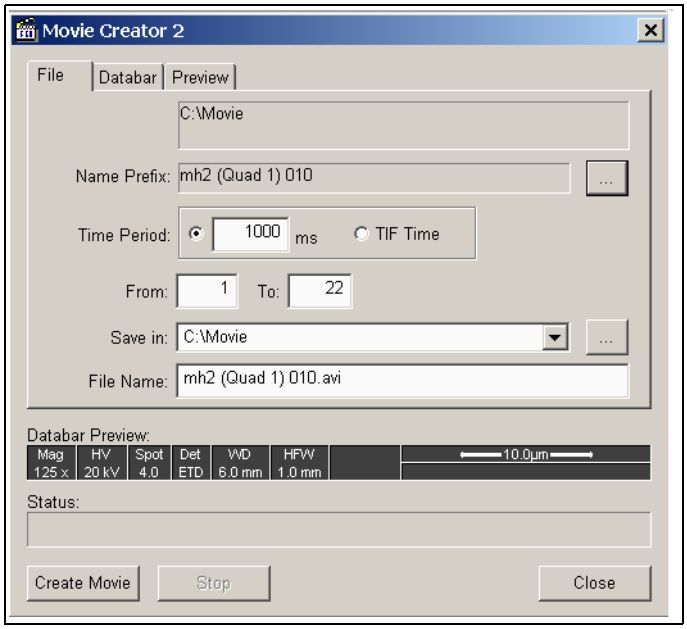
FEI Movie Creator

Start the **FEI Movie Creator** as the separate executable software from the C:\Program Files\fei\exe\Moviecreator2.exe to activate the tabbed dialogues for creating a movie from a sequence of TIF images.

File (tab)

The File tab contains the set-up facilities for creating a movie from a captured sequence of TIF images made while using the Movie facility.

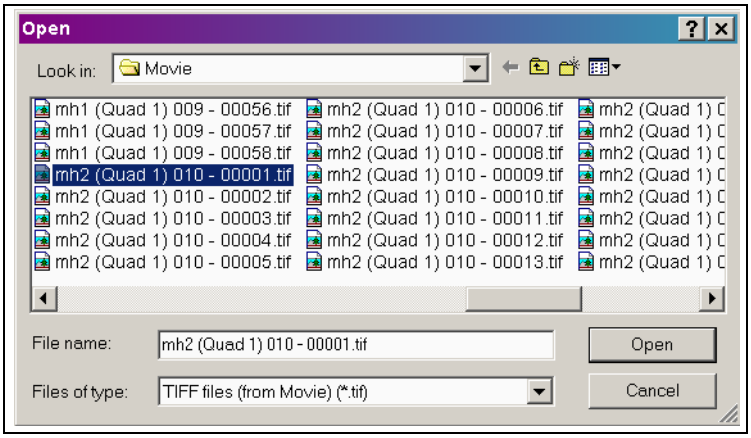
FIGURE 5-28 FEI MOVIE CREATOR TAB: FILE



Name Prefix:

Enter here the prefix label for the sequence of TIF images. Click on the dotted button to the right of the dialogue box to browse directories and files for the TIF sequence prefix.

FIGURE 5-29 BROWSE DIALOGUE


Open
Look in:
Movie
mh1 (Quad 1) 009 - 00056.tif
mh1 (Quad 1) 009 - 00057.tif
mh1 (Quad 1) 009 - 00058.tif
mh2 (Quad 1) 010 - 00001.tif
mh2 (Quad 1) 010 - 00002.tif
mh2 (Quad 1) 010 - 00003.tif
mh2 (Quad 1) 010 - 00004.tif
mh2 (Quad 1) 010 - 00005.tif
mh2 (Quad 1) 010 - 00006.tif
mh2 (Quad 1) 010 - 00007.tif
mh2 (Quad 1) 010 - 00008.tif
mh2 (Quad 1) 010 - 00009.tif
mh2 (Quad 1) 010 - 00010.tif
mh2 (Quad 1) 010 - 00011.tif
mh2 (Quad 1) 010 - 00012.tif
mh2 (Quad 1) 010 - 00013.tif
File name:
mh2 (Quad 1) 010 - 00001.tif
Open
Files of type:
TIFF files (from Movie) (*.tif)
Cancel

Time Period:

Either select a custom time for the playback of the movie by clicking on the millisecond radio button, or on the TIF time radio button to select real time (acquisition = playback). To find the best custom timing one may need to create the movie a few times. Unless the AVI file name is changed the next created AVI file will overwrite the last one made.

From: (Frame numbering)

Enter here the numbers of the starting frame and the ending frame. These will represent the sequence beginning to end.

Save in: (Path)

Enter here the path where the AVI file should be saved. Click on the dotted button to the right of the dialogue box to browse the directories for the path needed.

File Name:

Enter here the file name for the AVI file to be saved. If this is not filled in the default prefix (first image) will be used, and is filled automatically.

Databar Preview:

This displays the databar chosen from settings made in the Databar tag dialogue. Changes can be made by clicking on the Databar tab and reorganising the databar components.

Status:

This displays the progress of creation of the movie.

Create Movie

Clicking on the CREATE MOVIE button starts the creation process of the TIF files to a single AVI file.

Stop

The STOP button stops the creation process.

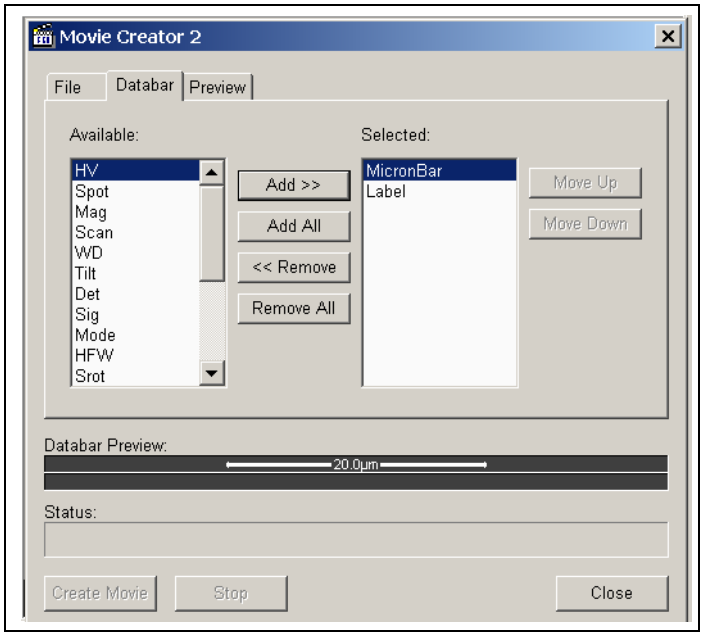
Close

The CLOSE button closes down the whole dialogue.

Databar (tab)

The **DataBar** Tab contains two lists, one labelled **Available** and the other **Selected**. Items in the Available list can be added individually or as a whole to the Selected list. The Selected list when completed contains all items that will be displayed in the DataBar at the base of the movie display. The order of the items in the Selected list can be moved up or down due to priority or preference. This will in turn change the order of the displayed items in the DataBar. Items can be removed from the Selected list singularly or in total back to the Available list. This facility does not affect the Quad and Full screen Databar and is only dedicated to the **Movie Creator**.

FIGURE 5-30 MOVIE CREATOR TAB:DATABAR



Available / Selected

Two lists, Available for all the items that can be entered in the Databar and Selected for all items that will be present in the Databar.

Add

Add one item from the Available list to the Selected list.

Add All

Add all items from the Available list to the Selected list.

Remove

Remove one item from the Available list to the Selected list.

Remove All

Remove all items from the Available list to the Selected list.

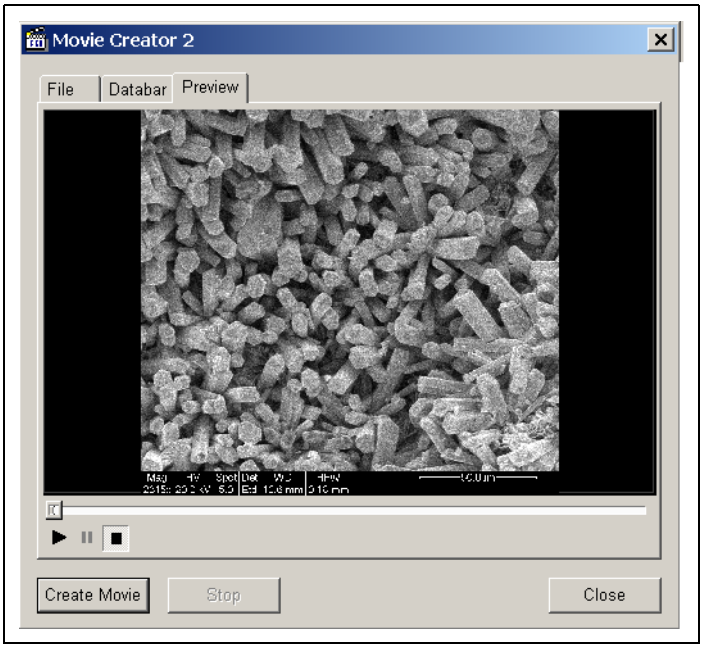
Move Up / Move Down

Move an item up or down in the Selected list.

Preview (tab)

Once the movie is created opening the Preview tab will automatically display the first image of the movie sequence. By clicking on the Play button the movie will start to play and the progress slider below the movie will move from left to right at a speed depending on the play timing of the movie.

FIGURE 5-31 MOVIE CREATOR TAB: PREVIEW



Start / Pause / Stop buttons

Click on these buttons to Start, Pause or Stop the movie. By holding the slider one can run forward or backwards through the movie.

Create Movie

Clicking on the CREATE MOVIE button will bring one back to the File tab dialogue and starts the creation process of the TIF files to a single AVI file.

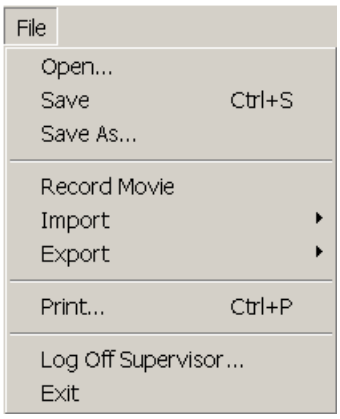
Close

The CLOSE button closes down the whole dialogue.

Playing a Movie

The AVI file movie can be played on the Windows Multimedia player installed on the system or exported to another Windows PC with more advanced movie editing programs. Programs used to play the movie need to recognise the *.avi file type.

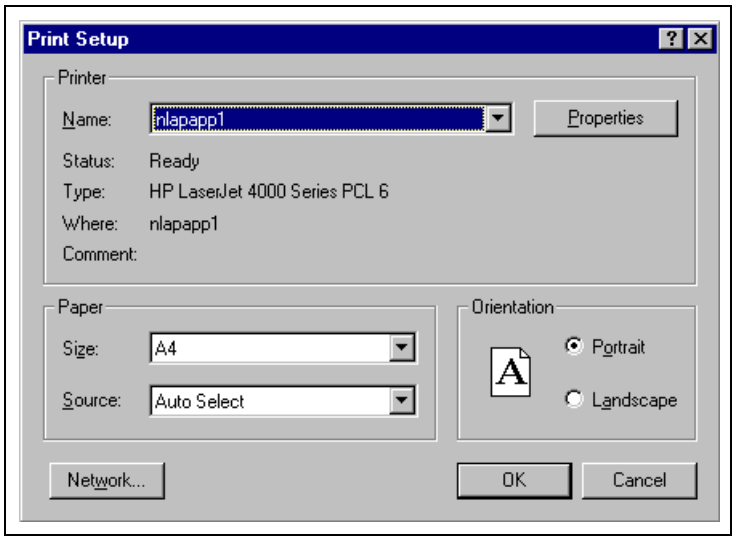
Image Printing



Print...

Clicking on PRINT... in the **File** menu, with the left mouse button, opens the printer setup dialog so that choice of printer and conditions can be established ready to print an image, or any other printable product from the microscope. The Print... word in the menu will only be highlighted when the active **Quad** is on **Pause**. Pressing **OK** in the printer dialog will activate the printer to print the job.

FIGURE 5-32 PRINTER SETUP DIALOG



.The following Table explains the print procedure.

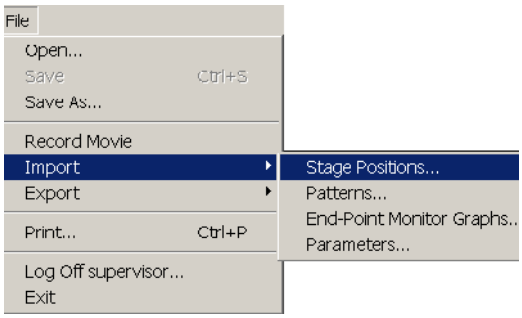
TABLE 5-23 IMAGE PRINTING PROCEDURE

Step	Action
1	Select a **Quad**. optimize the image conditions in that Quad.
2	**Photo** the image or open an existing image from memory into the Quad.
3	Click on **Print...** in the **File menu** or via the keyboard by **Ctrl + P**. A print dialog appears.
4	Satisfy the Print setup and click on **OK**.
5	The image set in the selected quad now goes to the printer.
6	**NOTE:** For higher resolutions the printer may need a larger memory buffer.

Import and Export

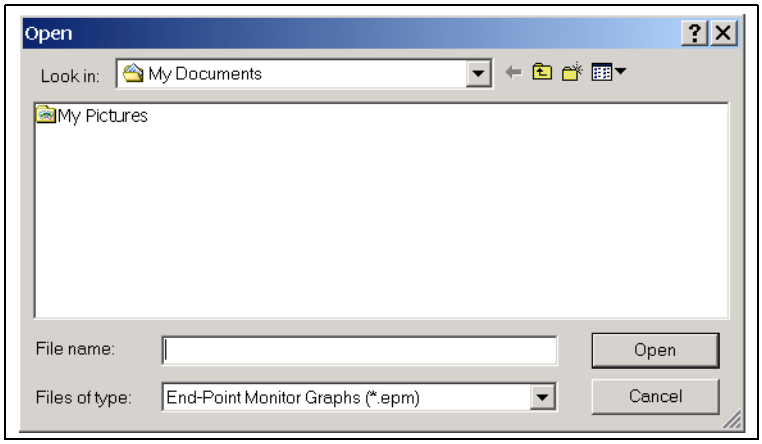
The Nova can Import and Export vital files for stage positions and EPM graphs. Other facilities will become available as the software progresses.

Import



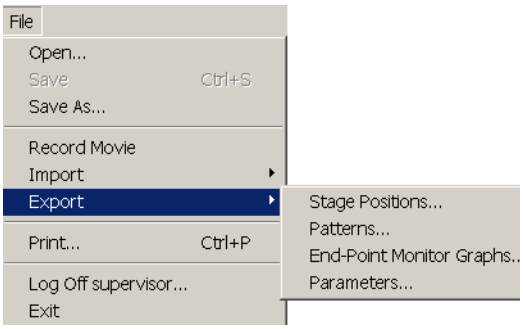
Click on the **File** menu and IMPORT to display the sub-menu choice. Choose the subject to import from the sub-menu and a OPEN dialog box displays dedicated to the subject chosen.

FIGURE 5-33 IMPORT OPEN DIALOG



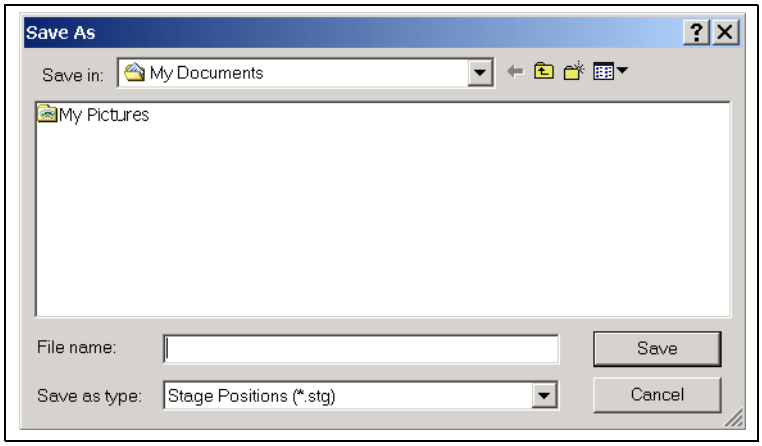
Choose the file to be imported and click on the OPEN button. The file will be imported and all dialogs disappear.

Export



Click on the **File** menu and EXPORT to display the sub-menu choice. Choose the subject to export from the sub-menu and a SAVE AS... dialog box displays dedicated to the subject chosen.

FIGURE 5-34 EXPORT SAVE AS...DIALOG



Enter the file name to be exported, locate the destination and click on the SAVE button. The file will be exported and all dialogs disappear.

Patterning

Patterning is the process of milling, depositing, or etching a pattern into the sample surface with the beam. During patterning, the selected beam unblanks automatically and uses digital beam placement to vector scan over a pattern. While patterning can be done with either beam, the electron beam is generally used for imaging and sometimes for deposition with patterns.

The ion beam is used to cut cross sections and tracks, drill vias, and deposit new material. In general, patterns need to be cut as quickly as possible, while maintaining sufficient edge resolution and preventing potentially damaging charge buildup.

During deposition, the beam is unblanked and a Gas Injection Valve is opened to begin deposition.

Multiple Gas Injection Systems (GIS) may be installed on your system. You select between milling, Pt deposition, Enhanced Etch, etc., by selecting an application file for a given pattern. You must define a pattern before an application file can be selected. A given application file will automatically select the appropriate GIS check box, calculate the proper dose, and set the dwell and overlap appropriate to the beam chemistry.

The GIS check boxes can be selected manually, but note that overlap and dwell should be set carefully with particular gasses in mind to avoid disappointing results.

Serial milling or deposition will always begin with the first pattern defined in the current image window and continue through patterns 2, 3, etc.

In Serial mode, a series of patterns could even be a combination of some to be milled and some to be deposited, but in general this is not recommended.

Patterning Tools

At the top of the Patterning Page is a selection of tools for creating, moving, sizing and deleting patterns.

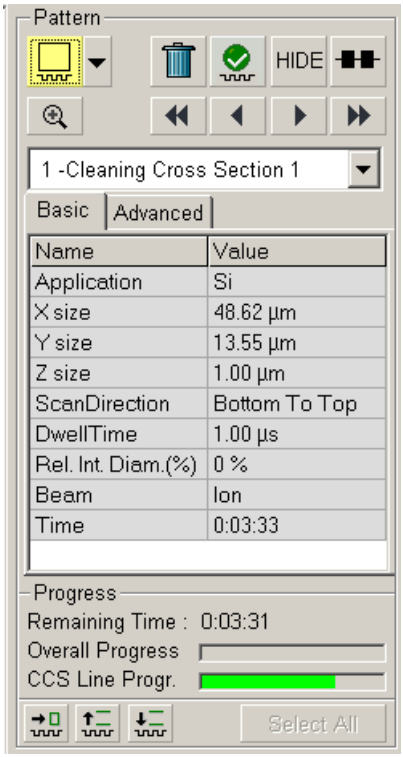
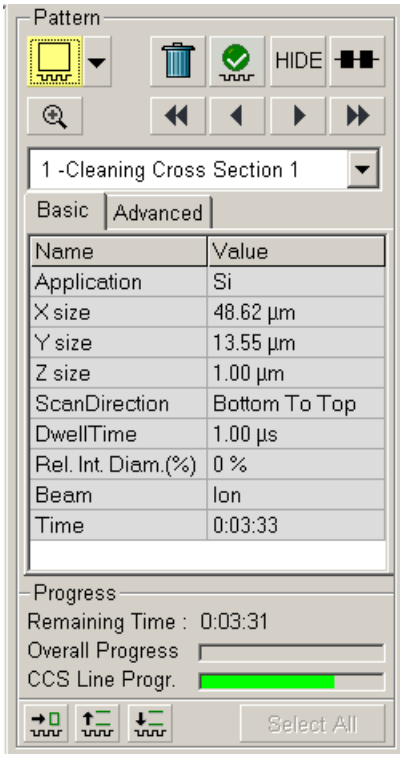


TABLE 5-24 PATTERN TOOL FUNCTIONS

Icon Button	Function
	Pattern Selector. Click on arrow to activate the dropdown list. When selection is made the blank area displays the relative Icon as follows: Rectangle Cleaning Cross Section Regular Cross Section Circle Line Polygon Bitmap (import) or Stream File Gray background = Inactive Yellow background = Active
	Pattern Zoom Pressing on the gray zoom button brings the drawn pattern in the active quad to maximum magnification with the image that is allowed. The button then turns yellow to indicate zoom is on.
	Trash Can (Delete). When pressed in displays a black staggered line surrounding the icon and deletes the present selected pattern.
	Pattern Activation Button (inoperative) When grayed out the button is in an inoperative state.
	Pattern Activation Button (enabled) When the green check mark is displayed, selected pattern is enabled.

TABLE 5-24 PATTERN TOOL FUNCTIONS

Icon Button	Function
	Pattern Activation Button (disabled) When pressed in, a reds cross appears through the green check mark. This will disable the current selected pattern. The pattern color on the image will turn gray, to show that the pattern will not be processed.
	Hide function. When pressed in displays a black staggered line surrounding the icon and hides the present selected pattern.
	Patterning Sequence. Serial: mills each pattern at a time in sequential order. Parallel: mills all patterns at the same time. When pressed in displays a black staggered line surrounding the icon.



Bitmap Pattern

From the patterning page a pattern is available that allows you to import bitmaps as a pattern. A bitmap file must be saved as a 24 bits bitmap. Each pixels consists of a red, green and blue component (RGB).

The **Red** component is currently not used. The **Green** component determines if the beam is blanked. Any other value then 0 will unblank the beam. The **Blue** determines the dwell time per pixel. If blue is set to 0 the dwell time of a pixel will be 100 ns. If blue is set to 255 the maximum UI dwell time is used. The dwell time for the pixels in between these values is linearly interpolated based on the blue component value between the 100ns and the maximum UI value and than rounded to the value from a (fixed) dwell time table with 124 entries.

When drawing a bitmap it is recommended to use black (0,0,0) for none milling points and blue for milling points.

TABLE 5-25 COLOR SETTINGS

Colour	Result
RGB 0 / 0 / 0 – black	Beam is blanked
RGB 0 / 1 / 0	Beam is on, 100ns min dwell
RGB 0 / 1 / 255	Beam is on, Maximum dwell time
RGB 255 / 255 / 255 – white	Beam is on, Maximum dwell time

Milling a bitmap procedure

1. Select patterning page control
2. Select the bitmap shape on the bottom of the pattern selection dropdown menu.
3. Drag a square on the screen that represents the area of patterning. The position of the square can be changed by dragging.
4. Select File in the properties menu and load the bitmap using the open dialog. The bitmap should appear in the imaging quad.
5. Modify Aspect ratio to Free or Fixed depending if it is required to stretch the bitmap.
6. Optimize other properties such as applications file, depth, leading edge etc.
7. Start patterning.

Stream File Pattern

A stream file, created as an ASCII text or binary file that addresses the patterning DAC directly, produces custom pattern files. Because a 12-bit DAC is used, the patterning field of view is divided into 4096 steps. The range in X is 0-4095, but in Y is approximately 280-3816. Y values outside of this range will be off the image area and may not scan correctly.

The following example scans 25 points in a 5 by 5 array, repeating 40 times. The dwell time is 9.6 µs for each point. The file must begin with an "s," indicating a stream file. The second line defines the number of loops the pattern mills, where one loop has the beam visiting each of the 25 pixels one time. The third line indicates the total number of X, Y coordinates, in this case 25.

The 96 figure represents dwell time in units of 0.1 microseconds. The range of dwell time is 0.1 µs to 4.6 ms, with 124 values distributed approximately logarithmically within this range.

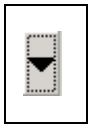
Note:
Stream files are for users who write their own programs for specific applications. Stream files cannot be created directly from xT.

s	96 2867 2867	96 1639 2048	96 2457 1639
40	96 1229 2457	96 2048 2048	96 2867 1639
25	96 1639 2457	96 2457 2048	96 1229 1229
96 1229 2867	96 2048 2457	96 2867 2048	96 1639 1229
96 1639 2867	96 2457 2457	96 1229 1639	96 2048 1229
96 2048 2867	96 2867 2457	96 1639 1639	96 2457 1229
96 2457 2867	96 1229 2048	96 2048 1639	96 2867 1229

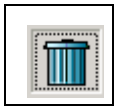
Magnification and Patterns

If your magnification is too high, milling certain patterns can use too much memory. If it is too low, the pattern corners become round and the edges get jaggy. A good rule of thumb is to pick a magnification where your pattern fills 35-50% of the screen.

Selecting a Pattern

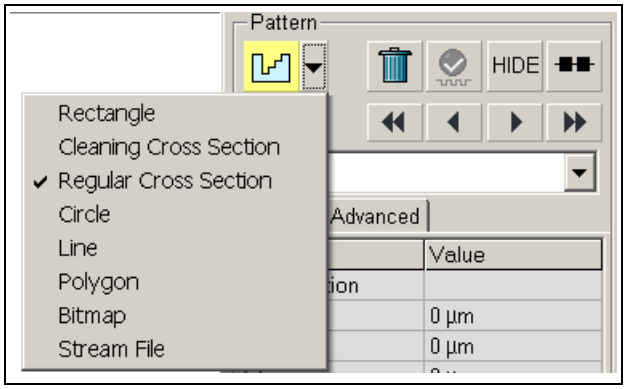


You must define a pattern before an application file can be selected. Select one of the patterns from the **Patterning** page with the PATTERN SELECTOR CURSOR. Once selected, the cursor is ready to draw a pattern onscreen. This will only be possible in the Quad or the Single screen whichever is active. Draw a suitable pattern size with the draw cursor in the Quad or Single screen. Use the PATTERN CONTROL CURSOR to move and resize the pattern by dragging it with the mouse.



When clicking on a new image window in Quad mode with the cursor that creates patterns, a slight mouse movement might produce a small unwanted pattern. If you create a small pattern accidentally, delete it by clicking on the DELETE button while the pattern is active.

FIGURE 5-35 PATTERN SELECTION



Editing Patterns

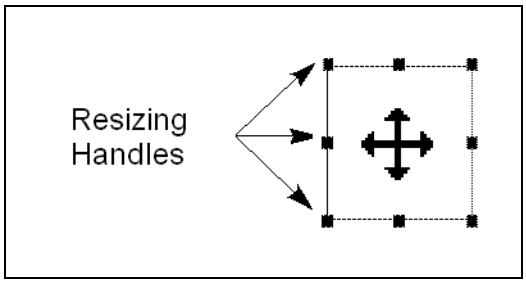
Once a pattern has been drawn, it can be modified. The following pages tell you how to control patterns by:

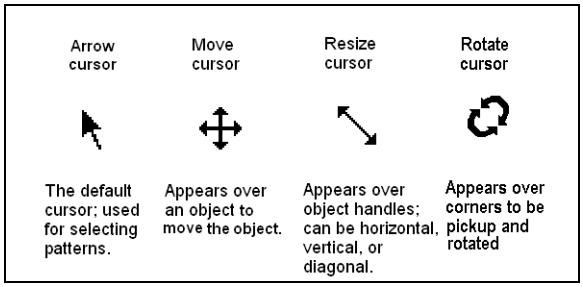
- Focus On
- Moving
- Resizing

Focus On Patterns

A Focused On pattern is denoted by the addition of resizing handles to the pattern outline.

FIGURE 5-36 RESIZING HANDLES / PATTERNING CURSORS




Arrow cursor
Move cursor
Resize cursor
Rotate cursor
The default cursor; used for selecting patterns.
Appears over an object to move the object.
Appears over object handles; can be horizontal, vertical, or diagonal.
Appears over corners to be pickup and rotated

Selecting Multiple Patterns:

Multiple patterns can be selected from the pattern selection box.

Pressing 'Shift' while the mouse is positioned over a pattern in the list enables continuous selection of more subsequent items

Pressing 'Ctrl' while the mouse is positioned over a pattern in the list enables adding/removing current cursor position to/from the selection.

Pressing 'Esc' will restore the previous selection.

Moving Patterns

Movement of patterns using the keyboard:

CTRL+ALT+LEFT - move to the left

CTRL+ALT+RIGHT - move to the right

CTRL+ALT+UP - move up

CTRL+ALT+DOWN - move down

Make sure the cursor is inside the boundary of the pattern and hold the Shift+Left mouse button will move a selected pattern by dragging and dropping it at a specified location. If the key is being held down, the keystrokes are automatically sent from the keyboard. In this case the first and second keystroke should move the pattern by one pixel, the third keystroke should move the pattern by three pixels. After the third keystroke, the counter of keystrokes should be cleared. This should be repeated until the key is released. Also this behaviour should be applied to ZOOM mode - 1 pixel of ZOOMED view should be used, not original view. This allows greater pattern placement precision. If the user moves mostly in a horizontal directions, there will be no vertical movement of the pattern. If the user moves mostly in a vertical direction, there will be no horizontal movement of the pattern.

Resizing Patterns

Hold the left mouse button and drag the pattern edge until the desired size is reached. Also achieved by entering values in dropdown list. Patterns can be Cut, copied or pasted by using the following entries in the edit menu, or the given short-cuts

Copy Ctrl + C

Cut Ctrl +X

Paste Ctrl+V

Cursors used with Patterns

Arrow cursors can be used for selecting, moving, resizing, and rotating patterns.

Select the ARROW toolbar button after defining a pattern to exit that pattern mode.

Serial Patterning

When you select serial patterning, from the Patterning Page, all patterns defined on the screen are milled *consecutively*; milling is completed on one pattern before moving to the next. Serial patterning is always used with cleaning cross sections.

Parallel Patterning

When you choose parallel patterning, from the Patterning Page, all patterns defined on the screen are milled *concurrently*. For example, if three lines are defined as milling patterns, one pass of the beam will be made on one, then the next, the third, back to the first, and so on until all three lines are milled to the depth selected for the first line.

With parallel patterning, the mill time is recalculated to include all the patterns that are displayed in the image window. Parallel patterning is typically used for regular cross section milling and to avoid redeposition of material on adjacent areas. Onscreen information is updated as the milling progresses.

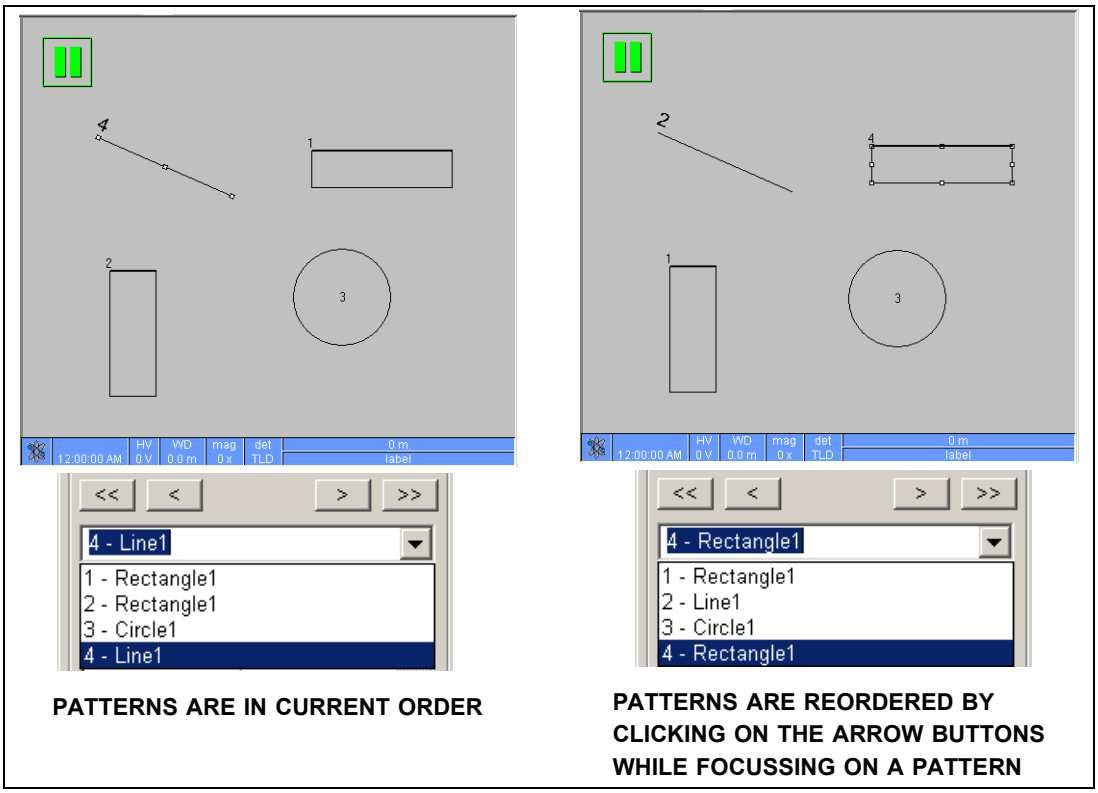
Patterning Progress

A patterning progress module, on the **Patterning** Page, displays the remaining pattern time in a progress window.

Milling Order of Patterns

Patterns are normally milled in the order they are created on the screen. The order can be changed by focusing on the pattern you wish to change to a particular position in the order and click on the single arrow in either direction to come to the order number required. To place a pattern at number one position click on the left double arrow while focus is on the pattern. This will bring it to number one position. For the last position click on the right double arrow in the same manner and the pattern will be made the last in order. The remaining patterns mill in the order in which they were created. You can also reorder the entire set by clicking on the patterns in the order you want them to mill.

FIGURE 5-37 REORDERING PATTERNS



PATTERNS ARE IN CURRENT ORDER

PATTERNS ARE REORDERED BY CLICKING ON THE ARROW BUTTONS WHILE FOCUSSING ON A PATTERN

Numbers display in the upper left corner of the rectangular patterns, left side for lines and center for circles to indicate the current pattern order.

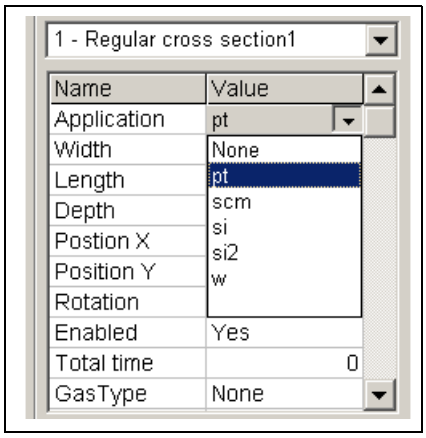
Application Files

Application files are files that are used with gas types for particular patterning and each one can assigned to a GIS. With multiple GIS's installed on your system you can select between milling, Pt deposition, Enhanced Etch, etc., by selecting a Application file for a given pattern. Milling on specific materials without gas can also be done more efficiently with the appropriate scanning conditions using the dedicated Application file for that material.

Choosing an Application File

Application files are found in the PROPERTIES list under APPLICATION on the **Pattern** page. Clicking on the right of the application entry will promote a dropdown arrow. Click on the arrow and a list of applications for the GIS system will be displayed. Click on the one required and it will reside in the APPLICATION slot in the PROPERTIES list. This is now the active application file for the GIS. The appropriate application file should be use with the gas type it was written for.

FIGURE 5-38 APPLICATION FILES CHOICE



The non-gas assisted application file

For the *Silicon* Application file the following patterning properties are defined:

TABLE 5-26 SILICON APPLICATION FILE (NON-GAS)

Properties	Si-XML	Description
Beam Type	Ion	
Dwell Time	$1.0e^{-6}$ s	The time the beam spends on a single pixel per pass.
Overlap	50%	Sets the beam diameter overlap.
Volume per Dose	$0{,}15e^{-9}$ m^3/s	Describes the amount of volume of material removed per charge. This used to be called sputter rate in previous dualbeam tools.

The parameters above are used for non-gas assisted milling. In this case and if the overlap is positive the mill time can be calculated based on the volume per dose parameter and beam current.

$$Volumeperdose = \frac{\text{volume}}{\text{charge}} = \frac{\text{cubicmicro ns}}{\text{nanocoulom b}} = \frac{\text{cubicmicro ns}}{\text{beam current} \times \text{time}}$$

Therefore:

$$\text{mill time} = \frac{\text{cubicmicro ns}}{\text{beam current} \times Volumeperdose}$$

For example, create a filled box pattern 5 µm x 5 µm x 2 µm as X, Y, and Z values (the desired volume of material to be milled: 50 cubic µm) and choose 500 pA (0.5 nA) which is 0.5 nanocoulombs per second.

Therefore:

$$mill\ time = \frac{50\,cubicmicrons}{0.5\,nanocloumbs\ per\ second \times 0.15} = 666.6\ sec. = 11\ min.\ 6\ sec.$$

If you change the Z depth from 2 to 4 microns, the desired volume would be twice larger and the milling time displays 22 min. 13 sec. Doubling the beam current cuts milling time in half.

The gas-assisted application file

For the Platinum Application file the following patterning properties are defined:

TABLE 5-27 SILICON APPLICATION FILE (GAS)

Properties	Pt Dep	Description
Beam Type	Ion	
Dwell Time	$1.0e^{-6}$ s	The time the beam spends on a single pixel per pass.
Overlap	0%	Sets the beam diameter overlap.
Volume per Dose	$0{,}5e^{-9}$ m^3/s	Describes the amount of volume of material removed per charge. This used to be called sputter rate in previous dualbeam tools.
Refresh Time	0	Is used to add additional waiting time between each pattern pass.
Blur	0	Will defocus the beam to increase deposition for large depositions.
Relative Interaction Diameter	150%	Adds additional pitch width to increase deposition rate. A 150% rel. int. diameter results in a pitch of 2,5 times the spotdiameter.

The dwelltime, volume per dose and interaction diameter are material and beam specific.

Refresh time and blur can be added if required for certain applications. I.e. blur for depositing large area's. Refresh time for filling via's.

The relative interaction diameter induces a pitch between two spots. A relative interaction diameter of 0% and 0% overlapx results in a pitch of 1 time the beam diameter. A relative interaction diameter of 100% and 0% overlapx results in a pitch of 2 times the beam diameter.

TABLE 5-28 MATERIAL SPUTTER RATES AT 30 kV

Material	Volume per Dose (μm^3/nC)	Pt-XML	Volume per Dose (μm^3/nC)
C	0.18	Au	1.50
Si	0.27	MgO	0.15
Al	0.30	SiO_2	0.24
Ti	0.37	Al_2O_3	0.08
Cr	0.10	TiO	0.15
Fe	0.29	Si_3N_4	0.20
Ni	0.14	TiN	0.15
Cu	0.25	Fe_2O_3	0.25
Mo	0.12	GaAs	0.61
Ta	0.32	Pt	0.23
W	0.12	PMMA	0.40

Editing Application Files

If a milling depth of a certain application file is insufficient an additional application file can be created or the current application file can be edited.

For example when using the Si.XML file for milling a GaAs substrate will result in much deeper Z then defined. The following procedure shows how you can edit the application file.

- XT Application files are located in : *C:\Program Files\Fei\data\patterning application files* (*.xml extension)
- XML files can be edited in Windows Notepad®.
- Make a copy of the Si.XML file
- The required parameters can be modified to user requirements.
- When the actual milling depth is different from the desired milling depth the volume per dose should be modified to a value that matches the required depth. In case of the Si.xml mill on GaAs the depth can be measured to define a new volume per dose value.

In the XML file the volume per dose variable can be found at:

```
<VolumePerDose xmlns:dt="urn:schemas-microsoft-com:datatypes" dt:dt="r8">
0.15e-9
</VolumePerDose>
```

The $0.15e^{-9}$ variable for Si can be changed to $0.61e^{-9}$ for GaAs.

- For easy recognition the comment lines can be changed.

```
<!-- Application file for milling silicon (Si) without any gas -->
```

- If etching or deposition application files are changed it is recommended to make a copy of the original gas injector application file.
- Dependant on use of the etch/deposition application file one can choose to edit beam type, dwell time, volume per dose, refresh time, blur or interaction diameter.

A list of common volume per dose values (or sputter-rates) for various materials can be found in Table 5-29. These are all values for 30 kV. A total list of patterning file properties can be found in the following Tables.

TABLE 5-29 PATTERNING FILE BASIC PROPERTIES

Properties	Description
Application	Name of the application. This will set the material, beam and gas properties.
X / Y / Z size	Set the dimension of the finished structure.
Dwell Time	The time the beam spends on a single pixel per pass.
Relative interaction diameter	The interaction diameter for an infinitely small beam relative to the beam diameter.
Beam	The beam used for patterning
Total Time	The total time required to pattern this shape.

TABLE 5-30 PATTERNING FILE ADVANCED PROPERTIES

Properties	Description
Scan Method	Choice of scan type, either multiple scan or stairstep. Regular Cross Section only.
Multi-Passes	Number of passes can be entered here. Regular Cross Section only.
Scan Ratio	Enables a dose ramp (e.g. low at start to high at final face) to occur in the pattern to further speed up the sectioning process.
Aspect Ratio	Choice between free or fixed aspect ratio of loaded bitmap. Bitmap only.

TABLE 5-30 PATTERNING FILE ADVANCED PROPERTIES

Properties	Description
Position X / Y	Position of the pattern relative to the origin.
Rotation	Pattern rotation angle. Positive direction is counter-clockwise.
Enabled	If a shape is disabled then it is not included in patterning.
Gas Type	The name of the gas that must be used to pattern this shape (or ‘none’ if no gas is to be used).
Overlap X / Y	Sets the beam diameter overlap
Pitch X / Y	Sets the pitch between two spots.
Scandirection	Determines the final edge the pattern will scan towards when patterning.
Volume per dose	The volume of material that is removed per charge.
Saturation sputter rate	The maximum linear sputter rate for a given gas. Currently not used.
Refresh Time	The minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed.
Loop time	Time required for a single pass.
Area	The surface area of the pattern.
Scan Type	Scanning strategy used while patterning. This is either raster of serpentine scan.
Fill Style	For box and circular patterns one can choose either to mill a solid or only the frame.
Passes	The number of passes that the beam scans over the pattern.
Defocus	The defocus of the beam (WD change). This influences the Beam diameter and area.
Blur	Like Defocus, but specifying the (additional) diameter of the blurred spot.
Interaction diameter	The interaction diameter for an infinitely small beam. Influences the Total diameter.
Total Diameter	The combination of the beam diameter and interaction diameter. This influences the Overlap and pitch values.
Maximum dose per area	This describes the adsorbed gas layer, allowing a certain dose to be deposited at a higher rate than the saturation current density, allowing a temporary higher rate. (Currently not used).
Saturation current density	The current at which 63% of the saturation sputter rate is reached. (Currently not used).

TABLE 5-30 PATTERNING FILE ADVANCED PROPERTIES

Properties	Description
Total Volume Sputterrate	The speed at which material is removed or deposited. (Currently not used).

Multi-pass

The fastest way so far found to do the rough milling part of a cross-section at a given beam current is to do the equivalent of 2 or more "cleaning cross-section" patterns over the pattern area - i.e. a multi-pass pattern where one multi-pass is a set of line patterns that move from bottom to top of the patterned area. Each line mill contains the number of passes needed to reach a fraction of the specified depth where this fraction is equal to the depth divided by the number of multi passes.

The enhancement in the rate is because the beam is always milling on an edge which enhances the sputtering yield. If only one pass is made then redeposition effects tend to "backfill" the section - this prevents the SEM from seeing the full section face. By making several passes, typically 2 or 3, then a cleaner removal is achieved enabling the SEM to view into the cross-section at the 52^{o} angle.

AutoTEM already makes use of a similar function - in that program a series of narrow box patterns are used with typically 2 passes. The use of boxes rather than lines is to minimize the overhead of pattern creation for AutoTEM.

Two parameters are used:

Multi pass - number of passes

scan ratio - enables a dose ramp (e.g. low at start to high at final face) to occur in the pattern to further speed up the sectioning process

The Gas Injection System (GIS)

Gas Injection

The Gas Injection modules provides the capability to select the type of gas deposition or etch material.

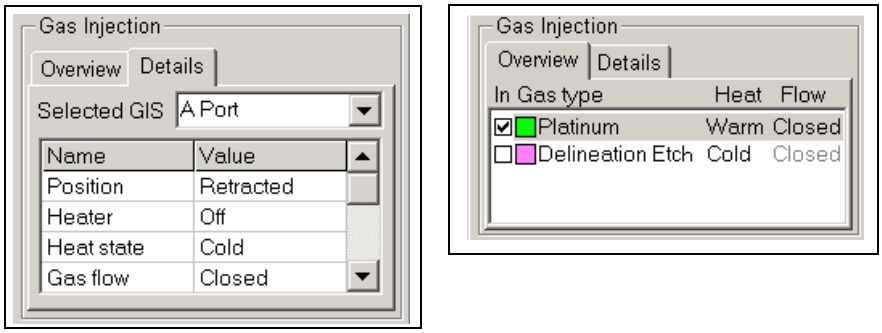
Overview Tab

On the OVERVIEW tab the tick box to the left of the Gas Injector, labelled IN, is the toggle for in or out activation of the injector. The gas type is the gas assignment to the port. The HEAT status is a toggle between cold or hot, and the FLOW status is a toggle between closed or open.

Details Tab

Clicking on the detail tab will display the characteristics of the active Gas Injector. The characteristics can be changed by entering the details to configure the injector.

FIGURE 5-39 GAS INJECTOR OVERVIEW / DETAILS



Gas Types

Gas types are used to deposit on or etch away material surfaces. A gas type will be allocated to each Gas Injector, and up to 5 gas injectors can be mounted on the system in total. If an OmniProbe is mounted then up to 4 GIS's can be mounted.

Choosing a Gas Type

The Gas Type files are found in the PROPERTIES list under GAS TYPE on the **Pattern** page. Clicking on the right of the entry will promote a dropdown arrow. Click on the arrow and a list of allocated gas types for the GIS system will be displayed up to the number of GIS's installed. Click on the one required and it will reside in the GAS TYPE slot in the PROPERTIES list. This has now allocated the GIS to be used with it's gas type.

When choosing from the list on the **GIS** module only the gas type GIS chosen in the Pattern PROPERTY EDITOR will be ready for active use.

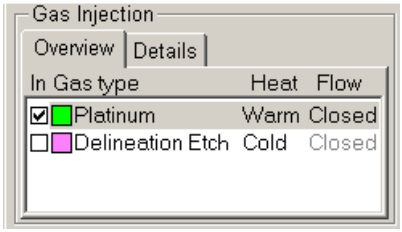
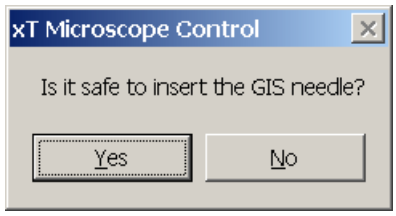
Setting up the GIS

The GIS to be used should be setup before patterning is started. It can be held heated and inserted but not open until it is necessary to use.

When not in use the GIS should be closed, cold and retracted. Leaving it closed, heated but retracted is also an option if it is to be used over

several patterns so that reheating is not necessary.

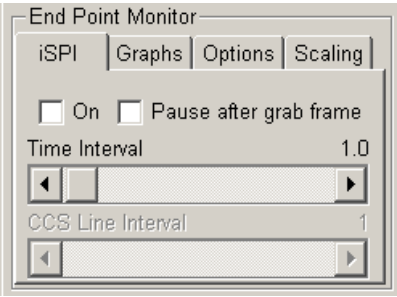
TABLE 5-31 SETTING UP THE GIS

Step	Action
1	Open the OVERVIEW tab in the **Gas Injector** module.  Either: Double click on the word COLD below the column HEAT for the GIS you need to use. or By clicking the right mouse button over the GIS module will open a dialog list where the word HEATER is highlighted. Click on HEATER.
2	The word COLD is replaced by a progress bar, which in turn is replace by the word WARM when the GIS is fully heated.
3	Tick the IN box at the start of the GIS chosen. A dialog appears asking for confirmation of insertion of the GIS.  Confirm the insertion if you know there is nothing obstructing its travel.
4	Either: Double click on the word CLOSED below the column FLOW for the GIS you need to use. That GIS will open. or Clicking the right mouse button over the GIS module will open a dialog list where the word FLOW is highlighted. Click on FLOW and the GIS will open. In normal operation, the GIS will be opened automatically when the patterning is started, if an application file with a gas type is chosen.
5	The GIS is now in operation and is either depositing or etching depending on the GAS TYPE chosen from the Pattern PROPERTY EDITOR.

The End Point Monitor (EPM)

The EPM

The EPM gives visual feedback as to the progress of a milling process. This device can be activated to start when patterning starts, stop when patterning is paused and restart when patterning is continued.



iSPI mode

Choose the required rate for the iSPI image

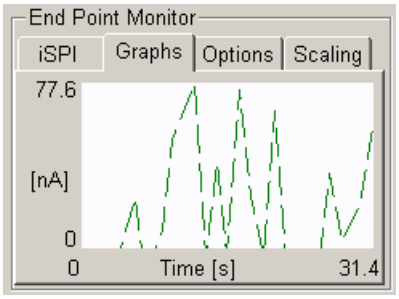
Unpause Electron imaging in Quad 1

It is possible to unpause other Electron beam quads with different detectors (e.g. ETD and STEM). Simultaneous images are grabbed in such a case.

Using iSPI mode with a Cleaning cross-section pattern, it is possible to take an Electron beam image every 'x' number of slices. This interval is selected via the 'CCS Line Interval'.

Using iSPI mode with other patterns, it is possible to take and Electron beam image after 'x' seconds. This interval is selected via the 'time interval' slider

The frequency Electron beam images can be selected via the sliders, while the patterning progress can be paused after Electron beam imaging, to allow for detailed inspection of the image, before progressing.



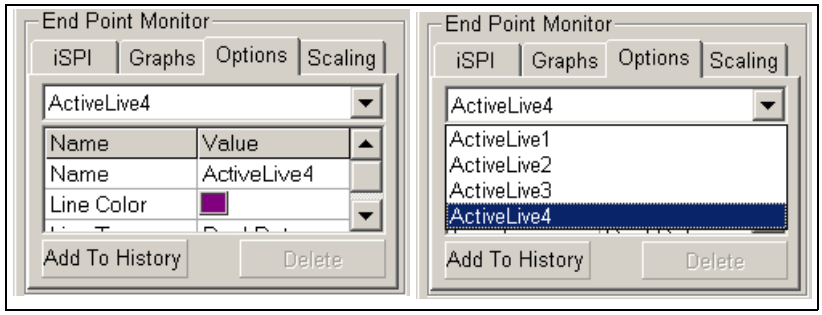
Graphs

The GRAPHS tab illustrates in live time the cutting depth progress monitored by specimen current. This means the milling progress can be observed as a colored graphical display.

Options

The OPTIONS tab allows selection of any number of milling processes being monitored to be graphically displayed.

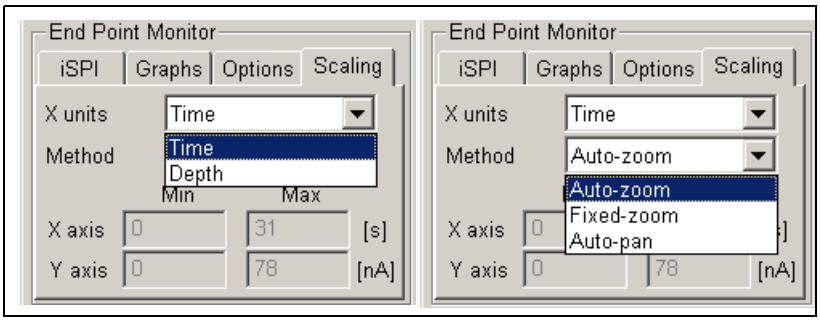
FIGURE 5-40 EPM OPTIONS



Scaling

The SCALING tab can be set via X UNITS to Time or Depth. This will correspond to how the progress is observed.

FIGURE 5-41 EPM SCALING



The operating METHOD can be selected from Auto-zoom, Fixed-zoom or Auto-pan.

Setting up the EPM for monitoring

To set up the EPM for use before patterning use the following procedure.

TABLE 5-32 SETTING UP THE EPM

Step	Action
1	Select the ACTIVE LIVE# option from the dropdown list in the **Options** tab.
2	Select the required conditions in the property editor in the **Options** tab, such as LINE TYPE and LINE COLOR.
3	Open the **Scaling** tab and select either TIME or DEPTH, from the X UNITS dropdown list, as the progress criteria.
4	Select either AUTO-ZOOM, FIXED-ZOOM or AUTO-PAN from the method dropdown list as the viewing range. AUTO-ZOOM will scale the entire progress to the viewing window. FIXED ZOOM can be setup by entering threshold max/min values for time (seconds) in the X AXIS, and max/min values for current (nA) in the Y AXIS. AUTO-PAN will keep the present milling position progressing in the viewing window while the past progress moves off screen.
5	Select the **Graph** tab to view the progress.
6	The EPM will continue with a baseline in the **Graph** display until patterning has started.
7	Start patterning.

Real Time Monitor (RTM)

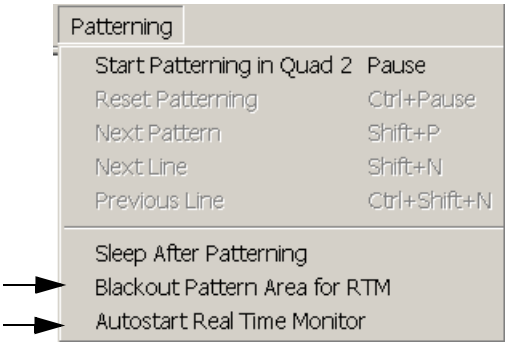
Introduction

The Real Time Monitor (RTM) provides immediate feedback on the patterning process. The patterned area is observed and in case of relatively slow scanning, the scan trajectory can be inspected.

RTM is typically used as an end pointing device by observing brightness differences in the detector signal. These result from contrast differences, e.g. when milling through layers of different composition on a stack of multiple materials or releasing a TEM foil from the Omniprobe tip.

RTM can be used with either beam (SEM and FIB), and with any of the pattern types that are available in the UI.

When starting patterning with the RTM activated, the pattern shape in the UI will be updated with real time image information. The patterned area information is updated based on the detector signal which is displayed in synchronization with the beam trajectory. Because the detector signal is synchronized with the scan of the patterning beam (usually FIB), the other beam cannot be used to make a live imaging while patterning (SPI mode - Simultaneous Imaging and Patterning -cannot be used simultaneously with RTM). As an alternative, it is always possible to grab snapshot with the SEM during FIB patterning while using RTM.



Blackout Pattern Area for RTM

When selected, the pattern background where the RTM is displayed, is made black in order to enhance the visibility of the RTM information. This is especially important for patterns with extremely large pitch or very thin lines.

Autostart Real Time Monitor

When selected, the integrated real time monitor (RTM) automatically starts with **Start Patterning** in the quad in which the pattern is drawn. RTM automatically stops when patterning is stopped or paused or when patterning job ends.

Starting and stopping RTM

The RTM will run if two conditions are met together:

1. Patterning is active;
2. The "Autostart Real Time Monitor" function in the Patterning menu is activated, or "imaging" in the ion quad with the pattern is unpaused.

These conditions can be realized in two ways:

1. Start patterning (start patterning button) while the "Autostart Real Time Monitor" function in the Patterning menu is checked;
2. Unpause the imaging in the same quad where a patterning task is running.

If the SEM image is live at the moment the RTM is activated, it is

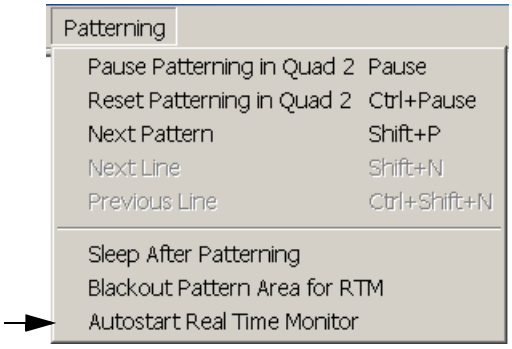
automatically frozen. After patterning (or when the RTM is turned off), SEM imaging will not be resumed automatically.

The RTM is automatically stopped whenever a pattern is reset (reset patterning button) or finishes because the total patterning has elapsed.

The RTM is stopped as well after a snapshot is taken in the same quad where the patterning is active. This is to prevent the RTM information from instantaneously overwriting the snapshot image. See further for more details.

Also when SPI mode is activated during patterning, the RTM is stopped.

To force the RTM to stop while patterning continuous, click on the pause button (normally used to start/stop imaging) with the fib-quad active. The same can be done to manually start the RTM (click on the pause button (normally used to start/stop imaging) with the fib-quad active.



RTM and FIB-snapshots

In the following, it is assumed that the patterning beam is the ion beam, and the pattern is defined and running in quad 2 (upper right). Similar behaviour is valid for other quads or when the SEM is the patterning beam.

The RTM is stopped automatically after a snapshot is taken in the same quad where the patterning is active). This is to prevent the RTM information from instantaneously overwriting the snapshot image. In order to have both RTM information and FIB-snapshot information available, the latter needs to be taken in a different quad, e.g. quad 3.

To do so, following steps have to be executed (of course, quad number can be different):

1. Select the "Autostart Real Time Monitor" function in the Patterning menu;
2. Define the pattern is required in quad two (FIB quad);
3. Set quad 3 to FIB as well;
4. Start patterning (quad 2). This will automatically start the RTM;
5. Activate quad 3 by clicking in it. Take snapshots as required.

Following these steps, quad 2 will continuously update with fresh RTM information as the ion beam is executing the pattern. In the mean time, it is possible to perform FIB-snapshots in quad as often as needed.

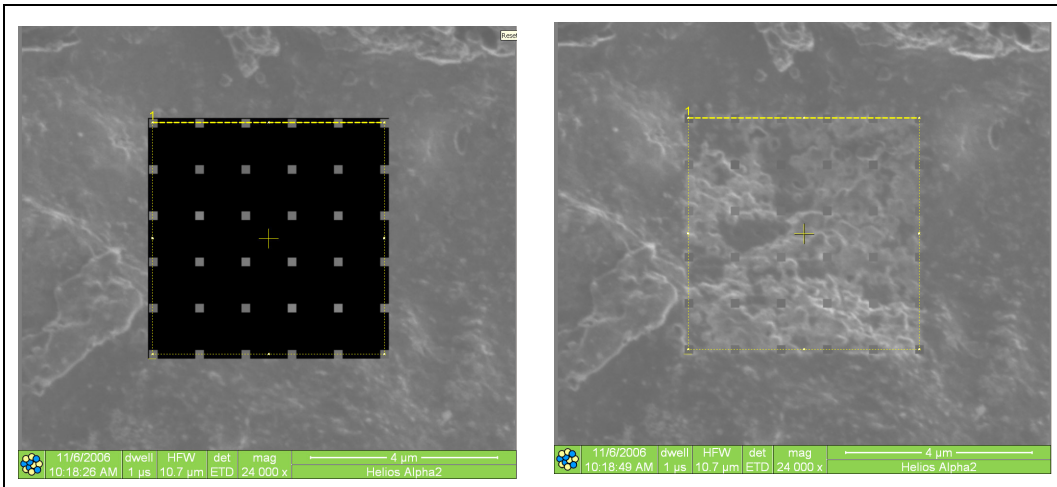
As an alternative, the RTM can be restarted manually by clicking on the (imaging) pause button in the same quad, as described above.

Blackout Pattern Area for RTM

When selected, the pattern background where the RTM is displayed, is made black in order to enhance the visibility of the RTM information. This is especially important for patterns with extremely large pitch or very thin lines.

The following images illustrate the difference with and without "blackout". Note that with the blackout, the visibility of the individual patterning pixels are greatly enhanced.

FIGURE 5-42 WITH AND WITHOUT BLACKOUT



With Blackout

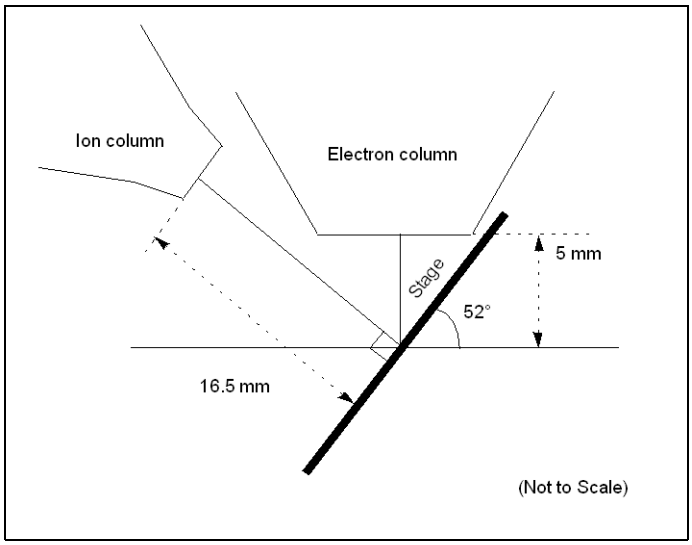
Without Blackout

Beam Coincidence

Beam Coincidence for the Electron and Ion Columns

The Electron and Ion columns are mounted as illustrated in the following figure, which shows the stage tilted to 52°. Coincidence of the beams occur at the eucentric tilt axis.

FIGURE 5-43 BEAM COINCIDENCE



Correcting Beam coincidence

Having completed the procedure in ‘Beginning your Session’, focus on a Quad with the Electron beam operating. Select an obvious feature on the sample and then switch to the Ion beam, from the Tool Bar, to see the same feature. Use the I-beam shift control to correct any offset in the coincidence of the two visualized features. The accuracy should be within 5 µm.

Test Pattern

A test pattern can be made with a simple pattern using the Ion beam and after observing it with the Electron beam to see that it has correct coincidence of beams.

Milling a Pattern

Start a Milling Pattern

When the procedure in 'Beginning Your Session' is satisfied then you can start to mill a pattern on the sample material. The procedure is as follows.

TABLE 5-33 MILLING A PATTERN

Step	Action
1	Select a pattern from the PATTERN SELECTOR on the **Patterning** Page, and draw a pattern in the active Quad.
2	Select a beam for patterning from the **Tool Bar**.
3	Enter a value in µms as the DEPTH in the PROPERTY EDITOR.
4	Select the milling aperture.
5	Focus and stigmate the beam on the area adjacent to the pattern.
6	If necessary, use the MUI SHIFT X and Y knobs or resize the pattern to correct positioning.
7	Snapshot a single frame to confirm the pattern position.
8	Click START PATTERNING on the Patterning menu or click on the START PATTERNING button on the **Tool Bar** to begin milling. The EPM automatically switches on.
9	Click PAUSE PATTERNING on the Patterning menu or click on the PAUSE PATTERNING button on the **Tool Bar** to pause milling.
10	Click RESUME PATTERNING on the Patterning menu or click on the RESUME PATTERNING button on the **Tool Bar** to resume milling.
11	Click on the STOP PATTERNING button on the **Tool Bar** to stop milling.

Stopping and Restarting

If at any time during milling or deposition you wish to stop in progress, click on the PAUSE PATTERNING icon on the Tool Bar.

When you stop and restart patterning, the software continues the patterning process where it left off. If patterning is restarted after patterns are modified, added, or deleted, patterning starts from the first pattern and all patterning completed clocks are reset to zero.

Fine Tuning Patterns

Use the MUI SHIFT X and Y knobs to fine-tune the image. Beam shifts are used in many applications, such as fine milling of cross sections to give a clean, vertical face to the section. Use Shift also to adjust for drift or charge effects. Grab-a-frame to monitor the change in mill position.

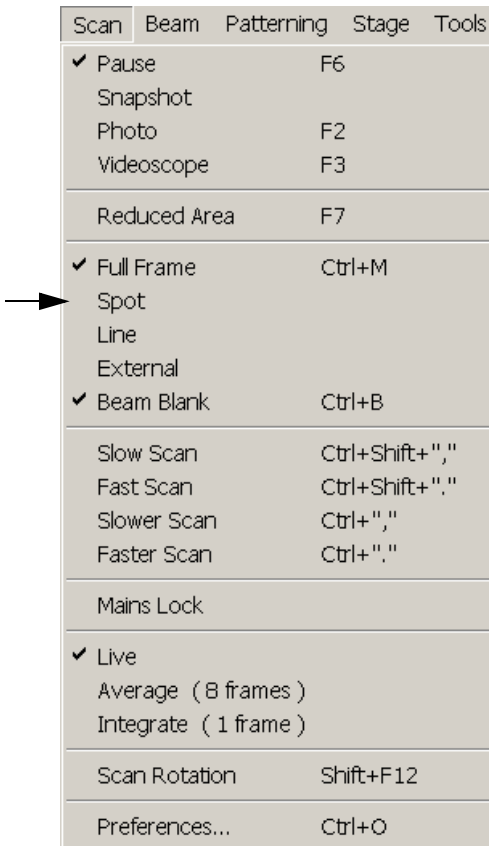
Beam Current/Milling Times

The appropriate beam current value depends on the sample to be milled and your experience with the sample material. Lower beam currents are less destructive and take longer to mill. The following are guidelines only. Specific parameters depend on your sample material and objectives.

TABLE 5-34 BEAM CURRENTS/MILLING TIMES BY APPLICATION

Milling Application	Suggested Beam Current/Milling Time
Typical cross sections (< 20 µm wide)	Try for a total time of 5-15 minutes, using 2-5 nA of current. Larger currents cause more damage around the recess and less vertical walls.
Large cross sections (very wide or deep ones)	Raise milling time to 15-20 minutes or more (beware of drifts).
Cleaning cross section	Use a value no less than one quarter to one half of the main current.
Drilling vias or cutting tracks	A drilling time from 1-4 minutes is adequate. The main limitations of short drilling times are difficulty in doing End Point Detection and the possibility of doing charge damage.

Milling in Spot Mode



Select SPOT from the **Scan** menu to place a single spot directly in the center of the screen. The cursor becomes an open green cross in the center of the screen. If the cursor is not moved the milling process will take place in the center of the screen. Click anywhere on the image to move the green cross to another position for spot milling.

TABLE 5-35 MILLING A SPOT

Step	Action
1	Move your feature to the center of the screen.
2	Select SPOT from the **Scan** menu. A open green cross is displayed in the center of the screen. Move the cursor over the spot required for milling.
3	Click on the START PATTERNING button in the **Tool Bar**.
4	To grab a frame, click on SNAPSHOT.
5	Click PAUSE once to resume SPOT mode scanning.
6	To exit SPOT mode, chose FULL FRAME.

Creating Cross Sections

A Typical Cross Section

Cross sections are cut in a stair step fashion to allow the exposed layers to be seen when the stage is tilted to 52°.

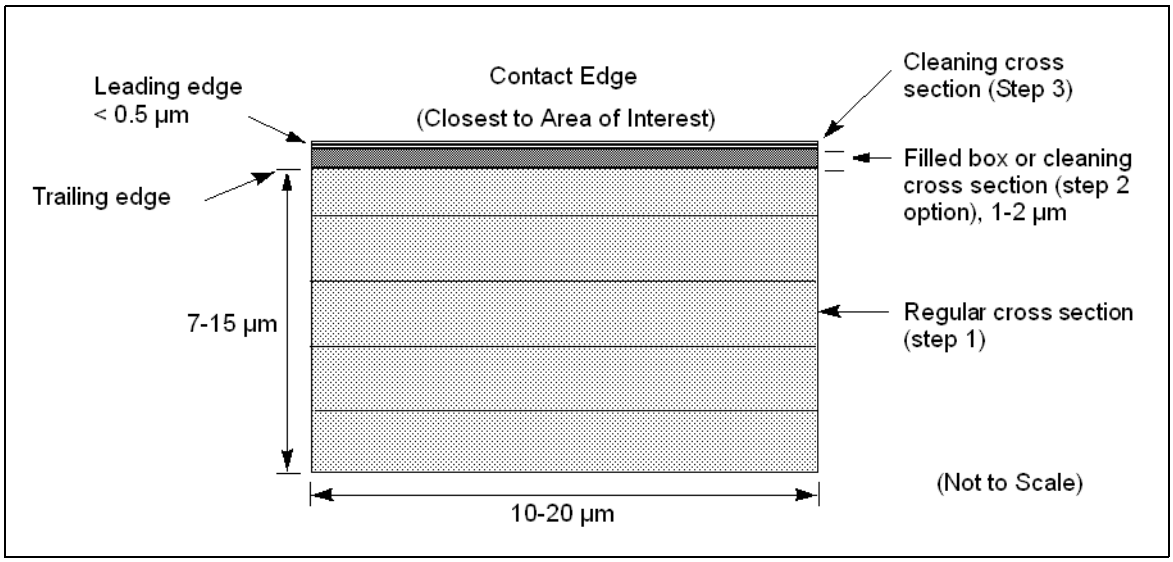
Mill a typical cross section in two or three stages.

1. The first stage is regular cross section with five superimposed box patterns sharing three common edges.
2. Optionally, use either filled box or cleaning cross section at a reduced current. (If the cross section is large, a second cleaning may be required at a lower current.)
3. Finally, use cleaning cross section.

The following figure shows the relationship of these pattern areas and their relative size.

A typical cross section is 10-20 µm wide by 7-15 µm tall with the dimensions and depth appropriate to the size of the target area of interest.

FIGURE 5-44 A TYPICAL CROSS SECTION



Use caution in positioning boxes if you are sectioning a very specific point. Use fine milling to expose the exact area of interest. For example, a 2 µm offset should be more than enough at 3 nA of current.

Calculate the outline as the height of the box relative to the depth to be milled. If you intend to view at 52° and see details 3 µm from the surface, then the original box should be at least 3 µm tall.

Making the Cross Section

Mill a regular cross section with five superimposed box patterns sharing three common edges.

TABLE 5-36 MAKING THE FIRST CROSS SECTION

Step	Action
1	Select a Quad by clicking in it, and the **E-Beam** icon from the **Tool Bar** and begin scanning.
2	Move the stage to where you want to mill the cross section.
3	Find the eucentric position.
4	Tilt the stage to 52°.
5	Save this position in the LOCATION list in the STAGE module. This is as far as the instructions take you in the section *'Beginning your session'*.
6	Align both beams by correcting the coincidence found in the section *'Beam Coincidence'*.
7	Optimize the I-Beam image.
8	Restore the stage position you stored in Step 5.
9	From the **Tool Bar**: Select the **I-Beam** icon. Set the I-Beam current to 150-5000 pA, depending on the size of the cross section.
10	Image briefly on the area to set the magnification and position.
11	Click SNAPSHOT to grab a I-Beam frame.
12	Open the **Patterning** page and do the following: Select REGULAR CROSS SECTION from the pattern tools menu on the **Patterning** page. Bring the cursor to the image area and draw a rectangular box about 2 µm from the area of interest.
13	While still on the **Patterning** page, within the property editor set the APPLICATION to '*si'* and enter the value for the DEPTH as needed. Press ENTER to update.
14	Click SNAPSHOT to grab a I-Beam frame.
15	Click on the START PATTERNING icon in the **Tool Bar**.
16	Use SNAPSHOT to update your image as desired by grabbing a frame from the Ion-Beam or E-Beam.

Use CLEANING CROSS SECTION from the pattern tools menu at a reduced current for this step.

TABLE 5-37 MAKING THE SECOND CUT (OPTIONAL)

Step	Action
1	From the **Tool Bar**: Set the I-Beam current to approximately ¼ of the beam current used for the first cut.
2	Click SNAPSHOT to grab a I-Beam frame.
3	Click CLEANING CROSS SECTION. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face is approximately 0.2 µm from the target area and the trailing edge extends just beyond the rough cut. **Remember to fill in the depth of your cross section in the property editor on the Patterning page.**
4	Snapshot another I-Beam frame to check alignment of the pattern to the feature.
5	Click on the START PATTERNING icon in the **Tool Bar**.
6	Select a new Quad by clicking in it, and the **E-Beam** icon from the **Tool Bar** and begin scanning. Click SNAPSHOT to grab a frame to view the E-Beam image.

Use CLEANING CROSS SECTION from the pattern tools menu for this final cut.

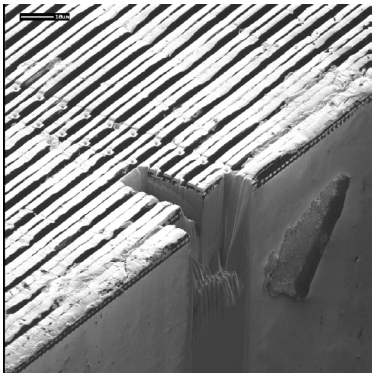
TABLE 5-38 MAKING THE FINAL CUT

Step	Action
1	If the cut is too rough, change the Ion beam current to 300 - 1000 pA. Adjust focus as needed.
2	In the patterning Quad click SNAPSHOT to grab an I-Beam frame.
3	Click CLEANING CROSS SECTION. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face crosses the target area and the trailing edge extends just beyond the rough cut. **Remember to fill in the depth of your cross section in the property editor on the Patterning page.**
4	Click SNAPSHOT to grab a I-Beam frame.
5	Click on the START PATTERNING icon in the **Tool Bar**.
6	Select a new Quad by clicking in it, and the **E-Beam** icon from the **Tool Bar** and begin scanning. Click SNAPSHOT to grab a frame to view the E-Beam image.

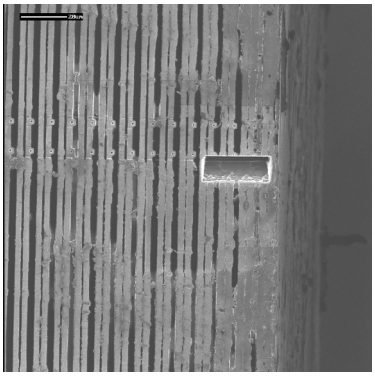
Viewing the Cross Section

After cutting the cross section, switch to SEM imaging and acquire an overview image of the cross section without the need to mode the stage. The following figure shows examples of some typical milling views of a cross section.

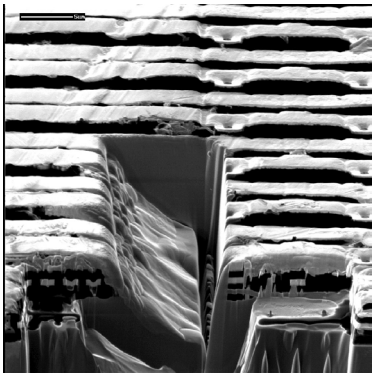
FIGURE 5-45 CROSS SECTION VIEWS



Perspective view of the cross section milled on the edge of a sample



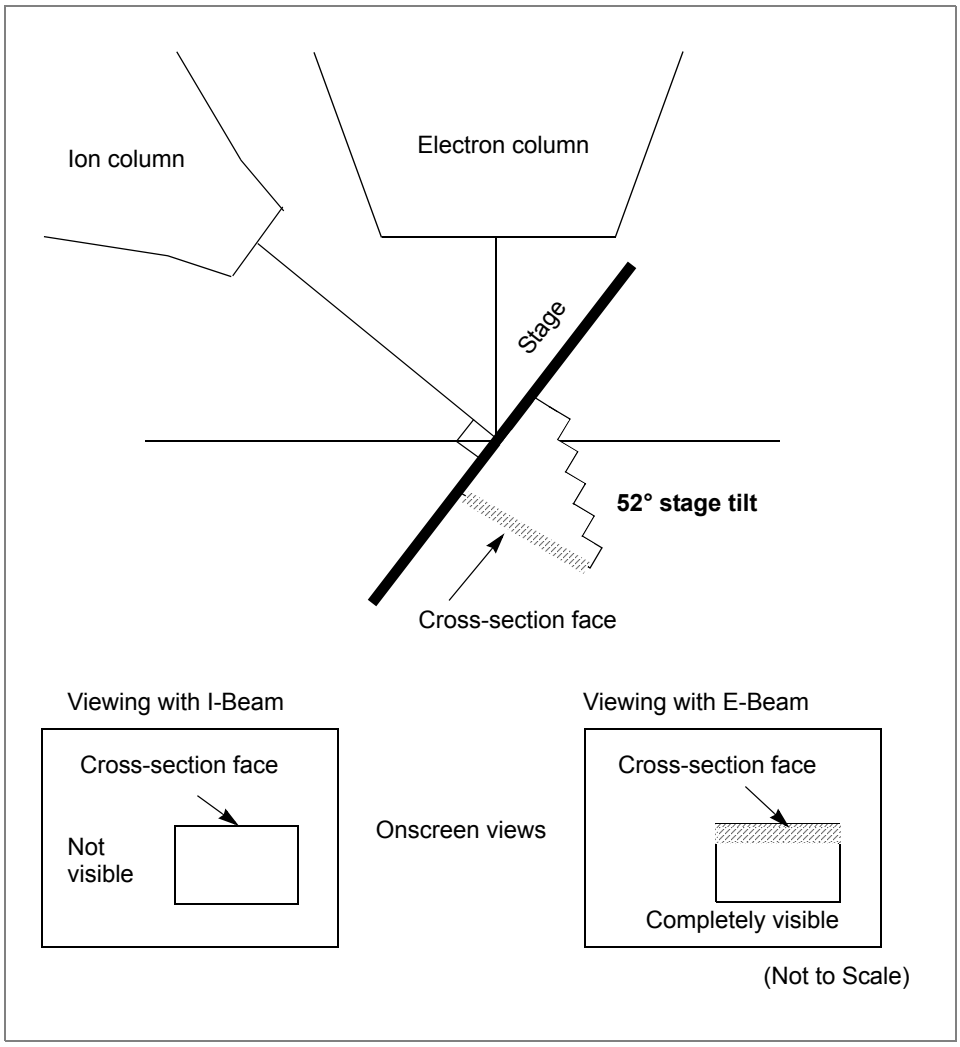
Top view of the cross section



Cross-section view. This view was done to show the geometry of the cross section.

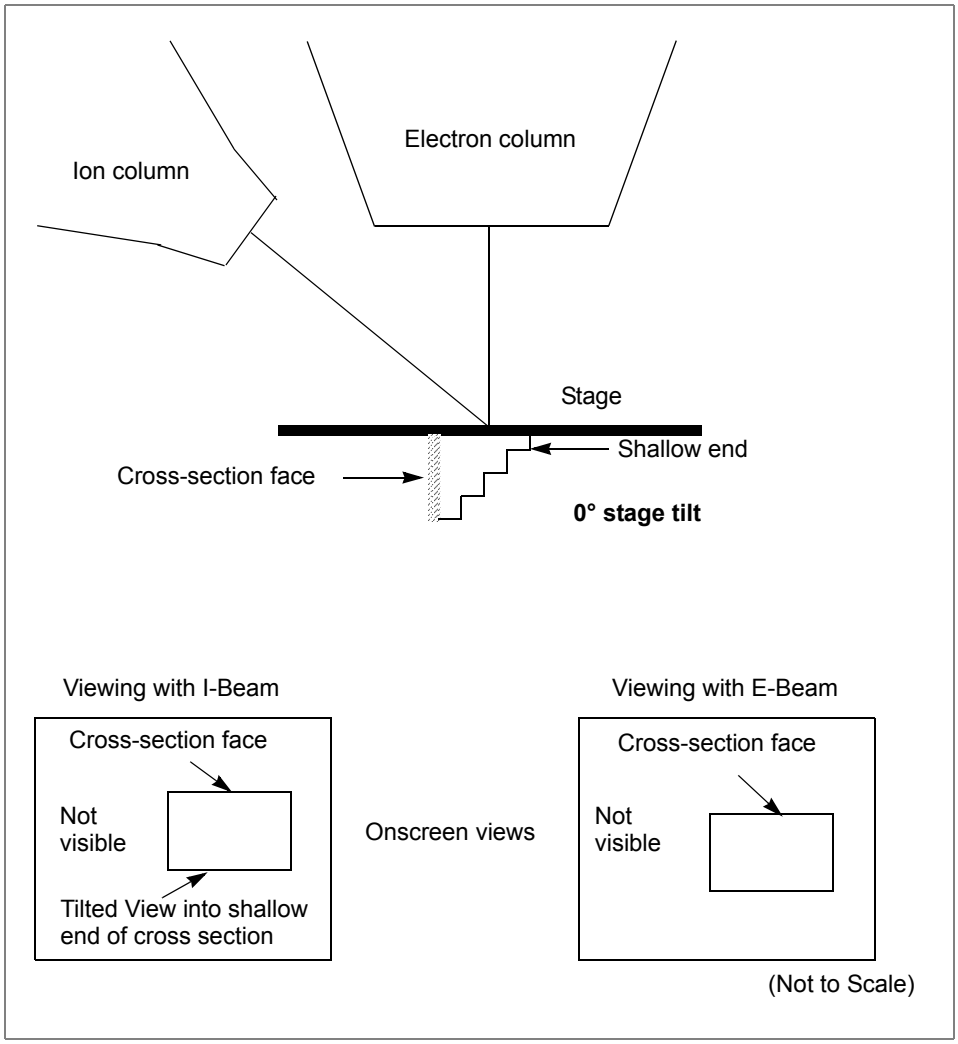
The following figure shows the relationship of the columns and stage to the face of the cross section during milling and how this is viewed onscreen, depending on whether you image with the electron or ion beam.

FIGURE 5-46 CROSS SECTION VIEWING DURING MILLING



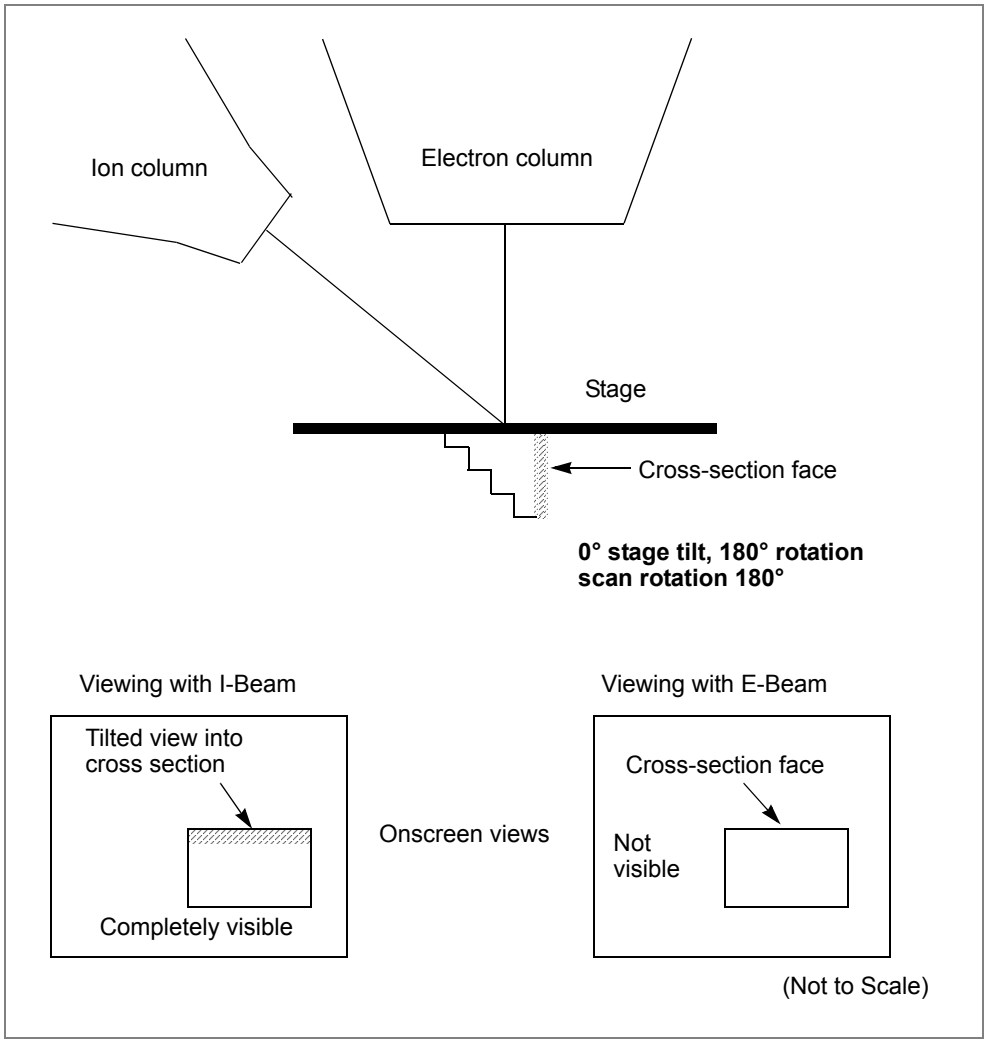
The following figure shows the onscreen view with the stage at 0° tilt, with both the electron and ion beam imaging views.

FIGURE 5-47 CROSS SECTION VIEWING AT 0° TILT

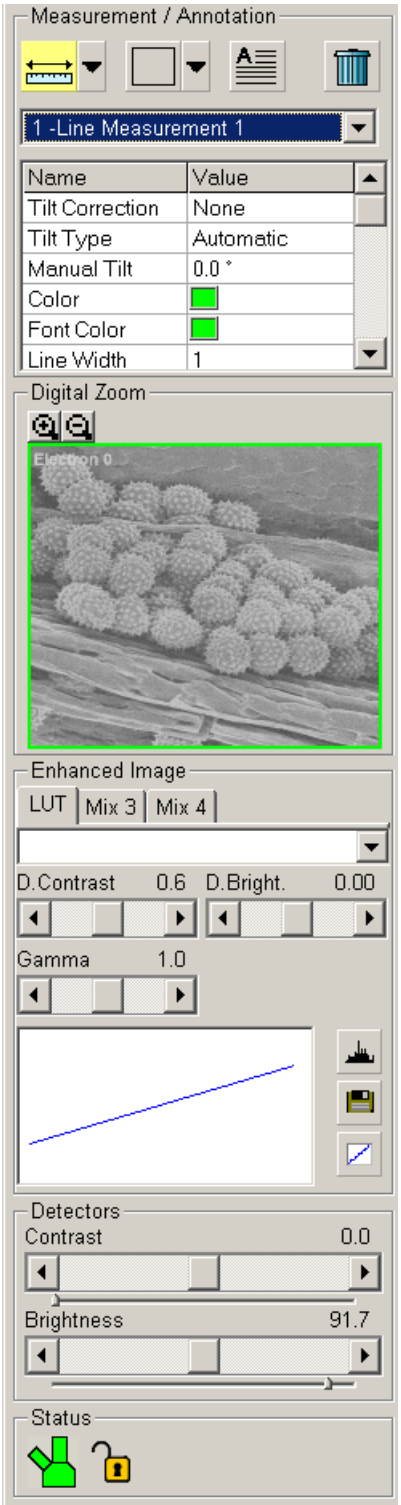


The following figure shows the onscreen views with the stage still at 0° tilt, but with both stage and scan rotation at 180°.

FIGURE 5-48 VIEWING AT 0° TILT ROTATED 180°



Using the Measurement functions

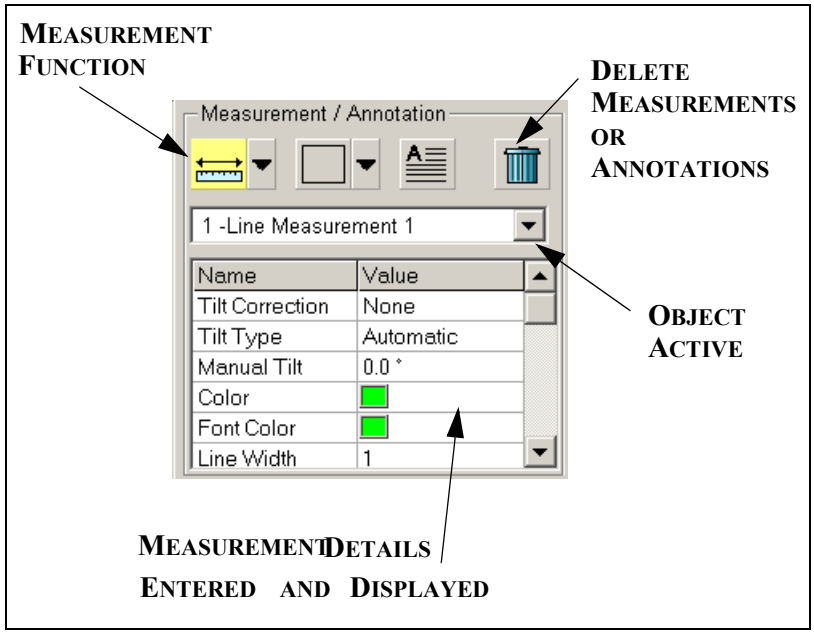


The MEASUREMENT functions found on the **Measurement and Annotations** page give the user many capabilities to measure distances, angles, diameters and areas etc.

Clicking on the appropriate symbol button at the top of the MEASUREMENT module will open a properties list where items such as Color, Font, line width, measurement type and text position etc. can be defined.

The graphic chosen can then be drawn on screen with that symbol cursor. Once the graphic is drawn, the ARROW symbol button can be clicked on to change the graphic in size or shape. If there are more graphics on screen the arrow button can also be used to focus on one in particular by clicking on the graphic when using the ARROW symbol.

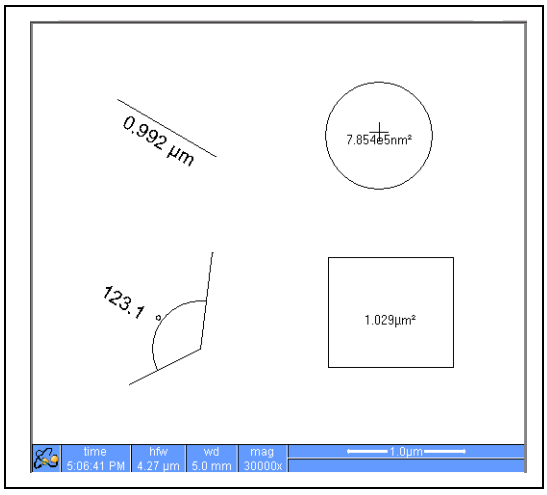
FIGURE 5-49 CONTROLS FOR MEASUREMENT



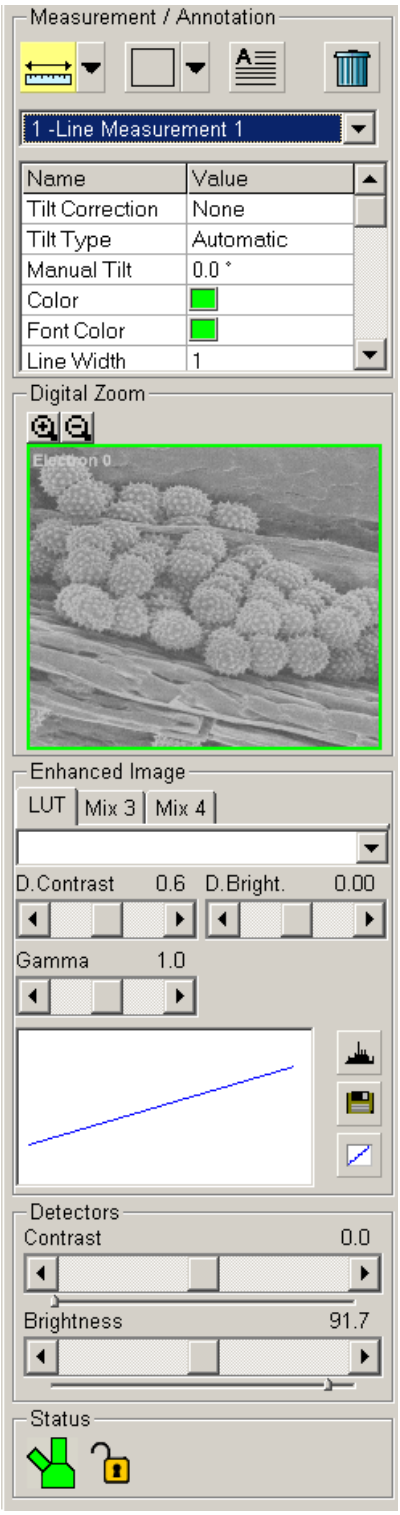
Use of Measurement

Measurement can be used to gain statistical information about a milled area by overlaying the shape with a measurement graphic to outline sizes within the area. The following procedure descibes how to use the Measurement functions.

TABLE 5-39 USING MEASUREMENT FUNCTIONS

Step	Action
1	Open the **Measurement and Annotations** Page. Click on the MEASUREMENT graphic symbol suitable for the milled item you need to gain measurements from i.e. rectangle for a standard rectangular patterned milled area.
2	Bring the cursor to the quad or screen area and draw the graphic over the milled area, to represent the milled shape. This can be done by dragging the cursor from the top left corner to the right lower corner of the shape.
3	When the graphic is drawn it can be sized and positioned by clicking on the ARROW symbol button and bringing the cursor back to the on screen graphic.
4	Click on the graphic to size and position the graphic correctly over the milled area.
5	Although there is a value already in the center or alongside the graphic, this is only one of a number of statistics available. These can be found in the PROPERTIES list for that graphic.
6	When there are more than one graphic the ARROW cursor can be used to gain information from each in turn. The ARROW cursor is only active on screen and changes automatically to the command cursor when over the UI.
7	Graphics that can be drawn with MEASUREMENT. 

Using the Annotations functions

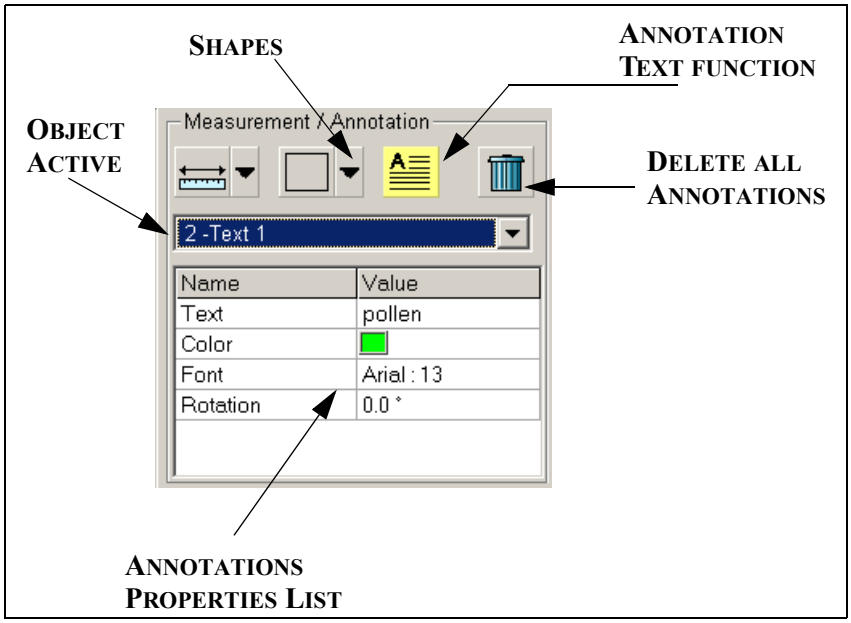


The ANNOTATIONS functions found on the **Measurement and Annotations** page give the user many capabilities to locate and label items that are of significant interest on the sample area.

Clicking on the appropriate symbol button at the top of the ANNOTATIONS module will open a properties list where items such as Color, Font, line width and text position etc. can be defined.

The graphic chosen can then be drawn on screen with that symbol cursor. Once the graphic is drawn, the ARROW symbol button can be clicked on to change the graphic in size or shape. If there are more graphics on screen the arrow button can also be used to focus on one in particular by clicking on the graphic when using the ARROW symbol.

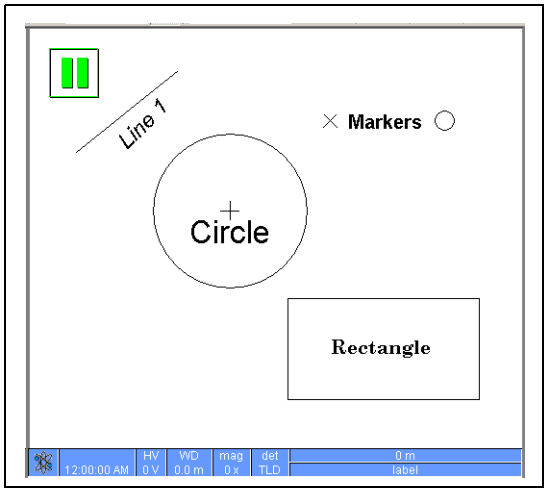
FIGURE 5-50 CONTROLS FOR ANNOTATIONS



Use of Annotations

Annotations can be used to graphically label items of interest. Text can also be used to add further information about the points of interest.The following procedure descibes how to use the Annotations functions.

TABLE 5-40 USING ANNOTATIONS FUNCTIONS

Step	Action
1	Open the **Measurement and Annotations** Page. Click on the ANNOTATION symbol required.
2	Bring the cursor to the quad or screen area and draw the graphic, if it was a annotation graphic symbol you chose. This can be done by dragging the cursor from the top left corner to the right lower corner of the shape. If you chose the TEXT symbol then just click once where you require text and a text box opens. Type the text into the text item in the PROPERTIES list. Click on the text with the left mouse button or press enter and the text will appear on the screen in the area of the box.
3	When the graphic is drawn it can be sized and positiond by clicking on the ARROW symbol button and bringing the cursor back to the on screen graphic.
4	Click on the graphic to size and position the graphic correctly over the sample area.
5	Condition in the PROPERTIES list can be changed to effect changes onscreen for text especially but also graphics for color etc.
6	The ARROW cursor is only active on screen and changes automatically to the command cursor when over the UI.
7	Graphics that can be drawn with ANNOTATIONS. 

Editing Measurements / Annotations

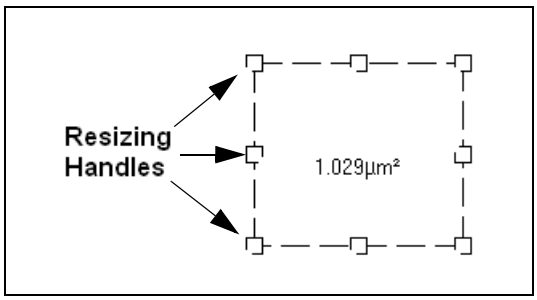
Once a measurement or Annotations symbol has been drawn, it can be modified. The following tell you how to control graphics by:

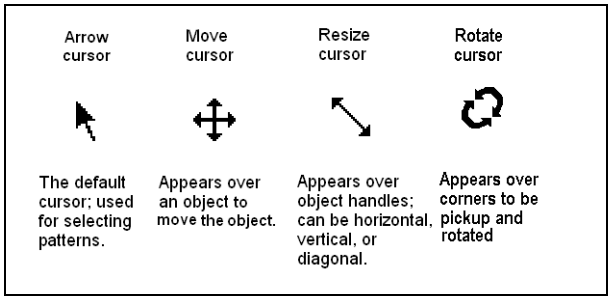
- Selecting
- Moving
- Resizing

Selecting Graphics

A selected measurement graphic is denoted by the addition of resizing handles to the outline.

FIGURE 5-51 RESIZING HANDLES / GRAPHIC CURSORS




Arrow cursor
Move cursor
Resize cursor
Rotate cursor
The default cursor; used for selecting patterns.
Appears over an object to move the object.
Appears over object handles; can be horizontal, vertical, or diagonal.
Appears over corners to be pickup and rotated

Moving Measurement Graphics

Make sure the cursor is inside the boundary of the graphic and hold the left mouse button while dragging the graphic.

Resizing Graphics

Hold the left mouse button and drag the graphic edge until the desired size is reached. Also achieved by entering values in the PROPERTIES list.

Cursors Used with Graphics

Arrow cursors can be used for selecting, moving and resizing graphics. Select the ARROW toolbar button after defining a measurement graphic to exit that graphic mode.

Using the Properties List

Whether to gain statistical information or to change a property of a measurement or annotation you can enter the PROPERTIES list for the graphic or text you have selected.

Some properties have a dropdown list so a choice can be made which will update on screen for the selected graphic.

Numerical values can be entered in text editors, with some properties, to effect the outcome of the graphic on screen. These will show a text cursor in the edit area when clicked on.

Delete buttons

The individual DELETE button, for either module, deletes only the item selected.

The DELETE ALL button, for either module, deletes all items on screen made only in either MEASUREMENT or ANNOTATIONS.

FEI User Management Software

The FEI User management software allows FEI Account Administrators, FEI Supervisors and FEI Microscope Users to organise users and accounts. It allows the creation and removal of user accounts, the setting of user passwords and group membership, as well as the copying and removal of user data.

You can start the software by clicking the desktop icon (Start\Programs\FEICompany\UserTools\FEIUsermanagement.exe). This brings up the **Log On** dialogue box, containing **Username** and **Password** text fields, for entering the User Management software.

Control possibilities

Context menu

You can reach some context options by clicking the right mouse button. The use of these options is the same as described below.

Drag and Drop actions

Instead of using menu options, you can sometimes simply drag and drop items from one icon to another (set user group).

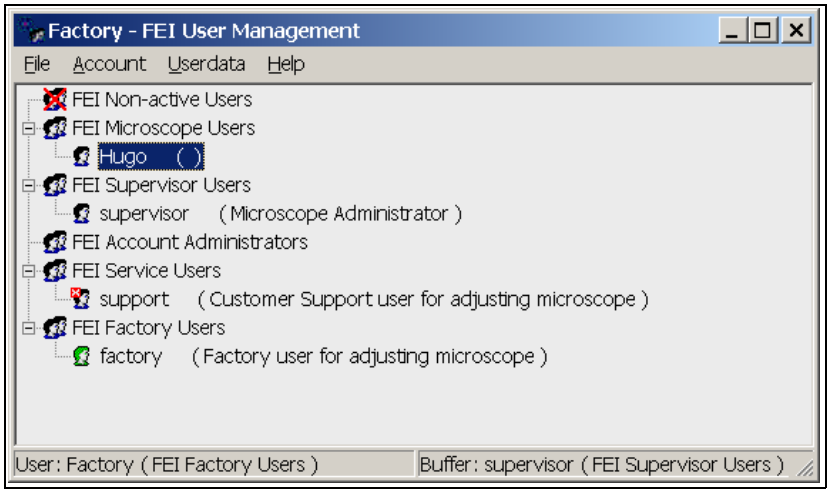
FEI Account Administrators

As the highest account level, FEI Account Administrators have rights that allow them to create and delete users and change their properties over the following user groups (in order of significance):

- FEI Account Administrator
- FEI Supervisor Users
- FEI Microscope Users
- FEI Non-active Users

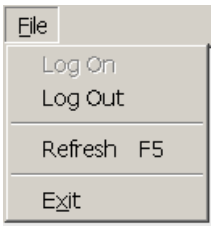
Each of these accounts has its own opportunity to operate the **xT microscope Server** and **Control** software. The first FEI Account Administrator is created during the system installation.

FIGURE 5-52 FEI ACCOUNT ADMINISTRATORS OVERVIEW


Factory - FEI User Management
File Account Userdata Help
FEI Non-active Users
FEI Microscope Users
Hugo ( )
FEI Supervisor Users
supervisor (Microscope Administrator)
FEI Account Administrators
FEI Service Users
support (Customer Support user for adjusting microscope)
FEI Factory Users
factory (Factory user for adjusting microscope)
User: Factory (FEI Factory Users)
Buffer: supervisor (FEI Supervisor Users)

The File Menu

contains the following items:

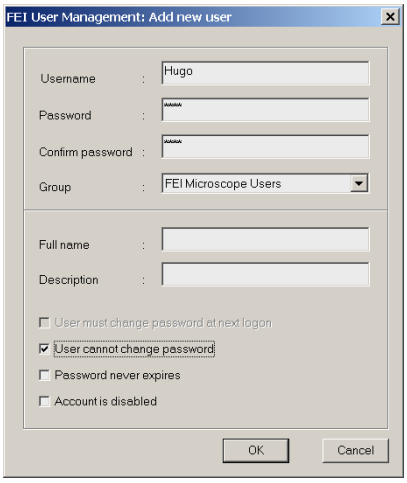


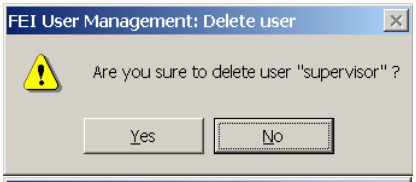
- **Login:** click to log in (active when user is logged out).
- **Logout:** click to log off (active when user is logged on).
- **Refresh (F5):** click to refresh the user tree.
- **Exit:** click to exit the FEI User management program.

The Account Menu

contains the following items, which are accessible only for **FEI Account administrators** (with the exception of set password function).

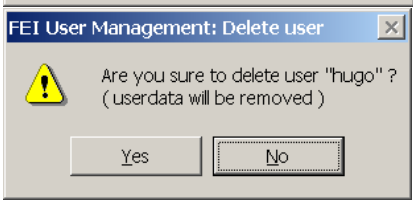
- **Create (Ins):** click to add a new user or supervisor.

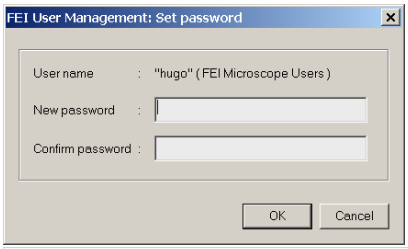




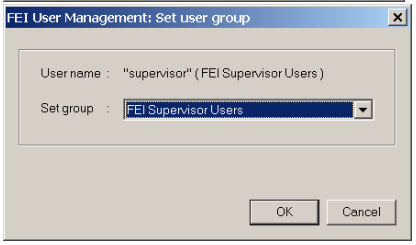
- **Remove (Del):** click to remove an existing user. The user must be highlighted first.

If an FEI Microscope User has user data, the account administator is warned that user data will be removed also. If any additional user is to be removed, that additional user's data is removed without warnings.

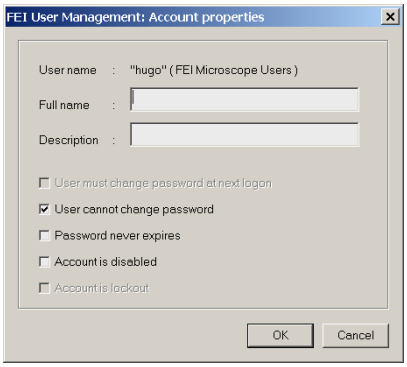




- **Set password:** click to make a password for the user. The user must first be highlighted in the tree.
  An FEI Account Administrator can change the password for any user from a lower level account. The password has to be confirmed twice.

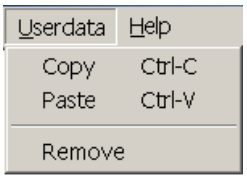


- **Set user group:** click to set the group for the user. The user must first be highlighted in the tree. When confirmed, the user is moved to selected group. When moving a user from the FEI Microscope Users group to the FEI Non-active Users group, his user data will be removed. A warning is displayed in this case.



- **Properties (Alt + Enter):** click to see and change the properties for that user. The user must first be highlighted in the tree.

The Userdata menu



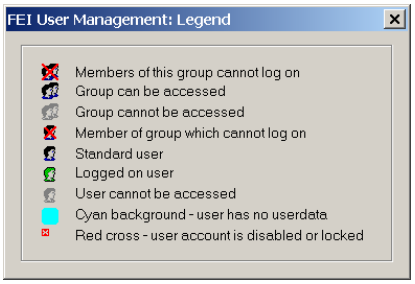
contains the following items.

- **Copy (Ctrl + C):** click to copy user data from a user of the same or a lower level group.
- **Paste (Ctrl + V):** click to paste user data into your own account or into the accounts of a lower group level. It is not possible to copy user data inside the FEI Supervisors User group.
- **Remove:** click to delete user data from a selected account of equal or lower group level.

The Help Menu

contains the following items:

- **Legend:** clicking provides an explanation of icons used in the tree.


FEI User Management: Legend
Members of this group cannot log on
Group can be accessed
Group cannot be accessed
Member of group which cannot log on
Standard user
Logged on user
User cannot be accessed
Cyan background - user has no userdata
Red cross - user account is disabled or locked

- **About:** displays the User Management software version and copyright.

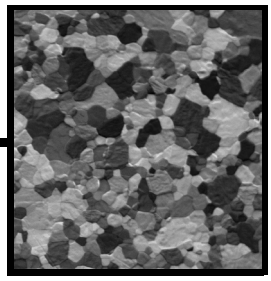
Account Logging

This accounting utility monitors user, log on / off actions, session time, filament lifetime and the UI status. It works with two log files located in c:\Program Files\FEI\data\accounting\:

- **accounting.tmp** is a temporary running file during use of the equipment at each user session, updated every 15 seconds so that any power down or windows crash situation can be time logged.
- **accounting.log** is permanent file to which the previous data are sent when a new session is started. This file is only readable by the FEI Supervisor User or higher level.

These files can only be deleted at factory or service level, each one is a text - CSV file so it can be loaded into Microsoft Excel for processing.

6 STAGES



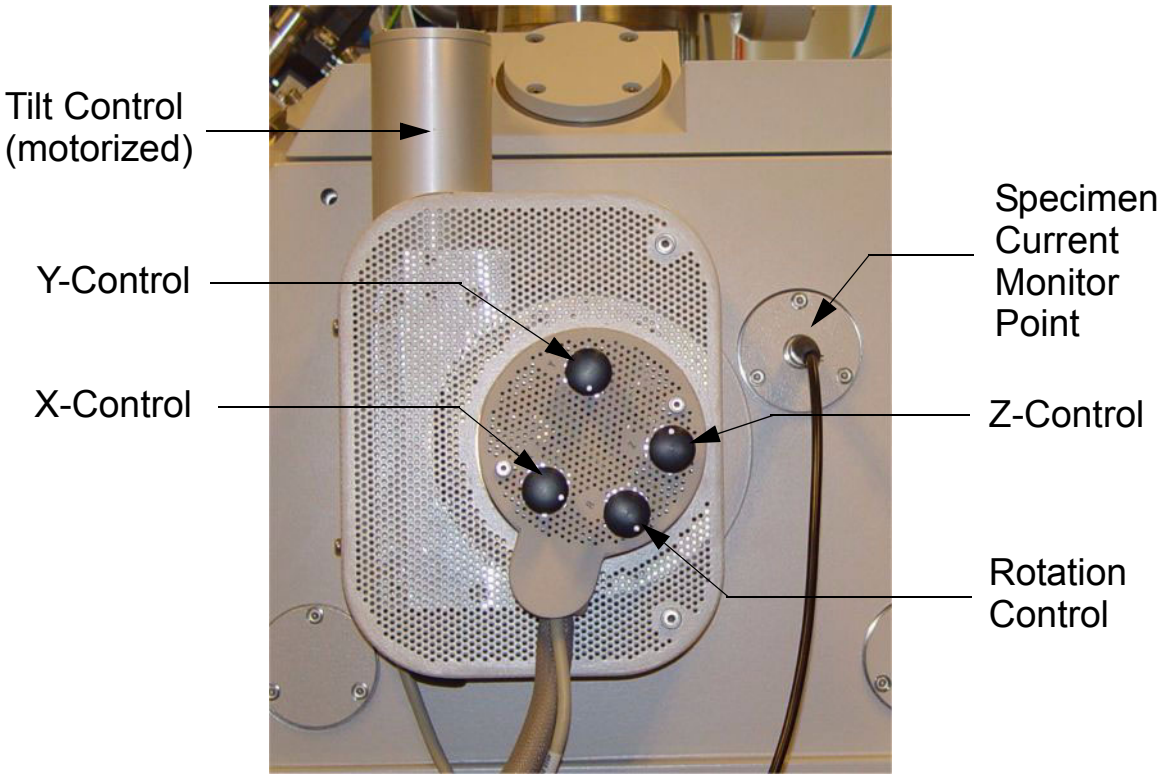
This chapter covers the following stages:

- NanoLab 200, 50 x 50 mm Motor 5 axes. (+ Manual Overrides)
- NanoLab 600, 150 x 150 mm Motor 5 axes

The software control for the stage is an integrated part of the overall control software.The Navigation Page layout remains the same so that it is easily recognised by users of either stage system.

NanoLab 200 Stage

FIGURE 6-1 NANOLAB 200 STAGE MANUAL CONTROLS



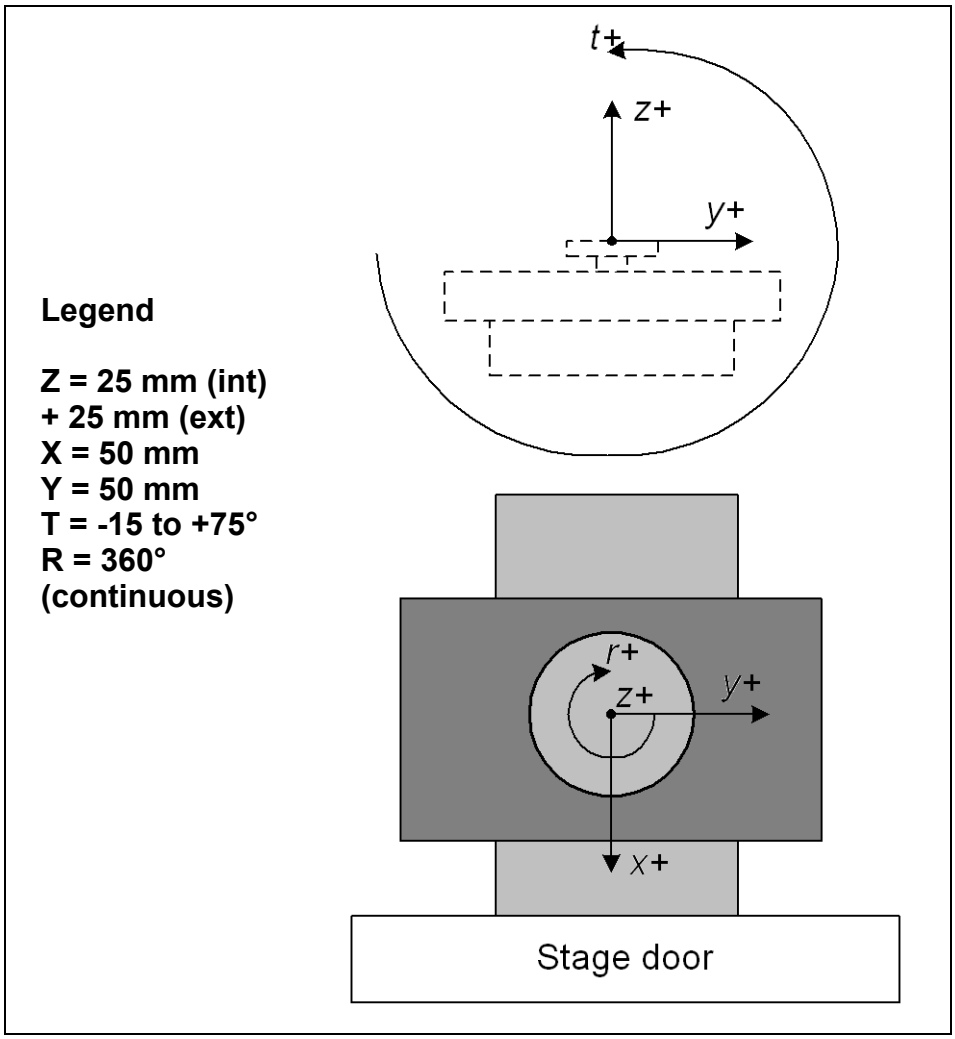
Stage movement

The motorised movements of the stage can be operated under software control for more advanced mapping and location. A live image area can be repositioned with either stage movement (manual or software) or beam shift.

NOTE: **When you move the stage or tilt the specimen, you may need to lower the magnification so you do not lose the feature of interest on the screen.**

Software controls for movement include the Shift, Get and Track and the Navigation Page functionality. You can access the Navigation Page by Clicking on the appropriate icon above the pages. The stage can be tilted 90^{o} total. The tilt axis always intersects the electron optical axis of the column at the same height (5 mm FWD) for eucentric tilt. When the specimen is positioned at this height, the specimen can be tilted in the eucentric plane.

FIGURE 6-2 NANOLAB 200 STAGE MOVEMENT

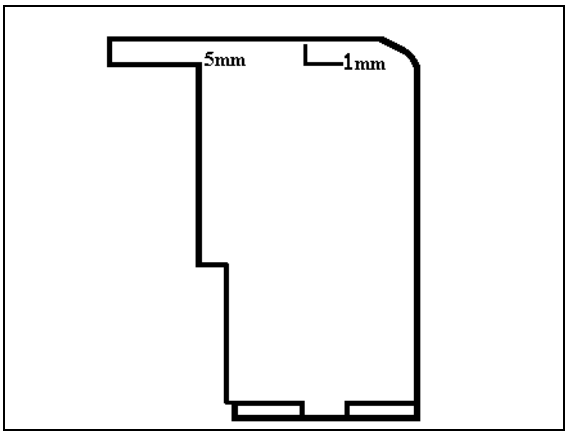


NOTE: By default, negative tilt is disabled by software interlock, as this may cause a conflict with insertion of gas injectors. To override the software interlock, contact your service engineer.

Using Z (height) adjustment

With the standard specimen holder it is possible to change the specimen height inside the chamber, to bring the sample to a eucentric position and have flexibility to then move Z from outside the chamber to another position if required. The internal Z range is 25 mm of movement, and the external Z range (5) is also 25 mm. This allows a flexibility to load large or different height specimens onto the stage by reducing the internal Z but still be able to manipulate the difference in height from outside.

FIGURE 6-3 NANOLAB 200 EUCENTRIC ADJUSTER



To set the specimen height to the eucentric position, and at the same time prevent any possibility that the specimen should touch the lens pole if the Z is increased, can be done as follows:

- Load a specimen onto the specimen holder.
- With the stage still open adjust the external Z (5) to the highest position.
- Set the Eucentric Height Adjuster on the stage base.
- Bring the highest specimen or point on the specimen to the 2 mm position on the Height Adjuster by turning the internal screw of the specimen holder. Lock the position with the locking cone.
- Reduce the Z so that the specimen now coincides to the Eucentric position on the Height Adjuster by use of the external Z control (5).
- Close the chamber, and pump down.
- When the beam is switched on focus the sample and click on the Z<->FWD button icon on the Tool bar. The FWD will be recognized by the system as the value of Z in the Coordinates tab of the Navigation page.

Now the Z can be changed from the external Z control(5) around the eucentric position and further, but for safety, not less than 2 mm from the lens.

Standard Sample Holders

The NanoLab 200 stage has 1 standard holder and an interface piece for clamp holders such as the UMB Holder (option).

The 200 and 600 stages have eucentricity and therefore need to have a Z prime position at a set height from the stage rotation head surface to bring the sample surface to a eucentric condition.

The eucentric holder is screwed into the center of the rotation head of the stage. When the stub with specimen is fitted, by tilting the stage, the position of tilt should be at the plane of the specimen. The specimen should not be of excessive height as this will not work. The specimen should be within 1 to 2 mm thick.

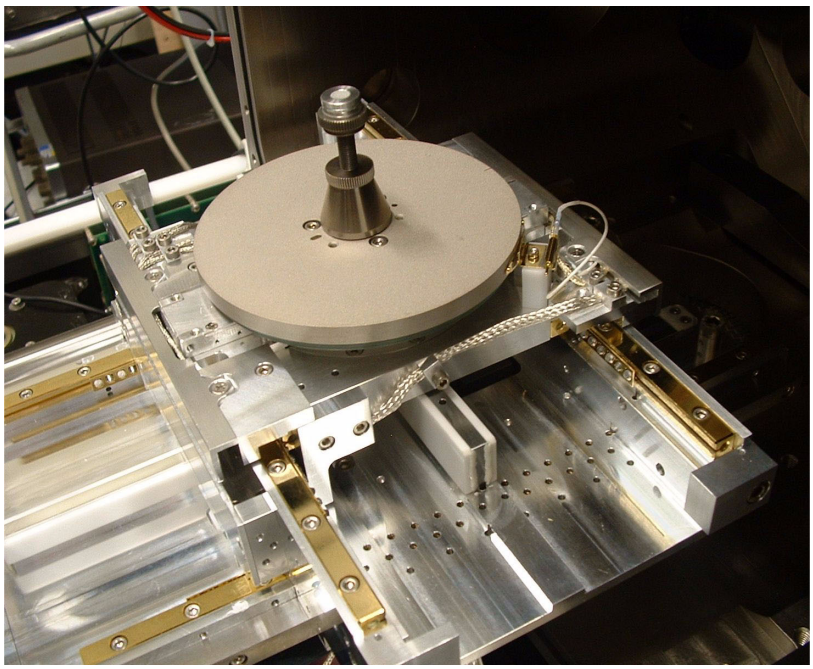
FIGURE 6-4 200 STANDARD SAMPLE HOLDERS

Standard Single Sample Holder

Stage interface piece for UMB

NanoLab 600 Stage

FIGURE 6-5 NANOLAB 600 STAGE

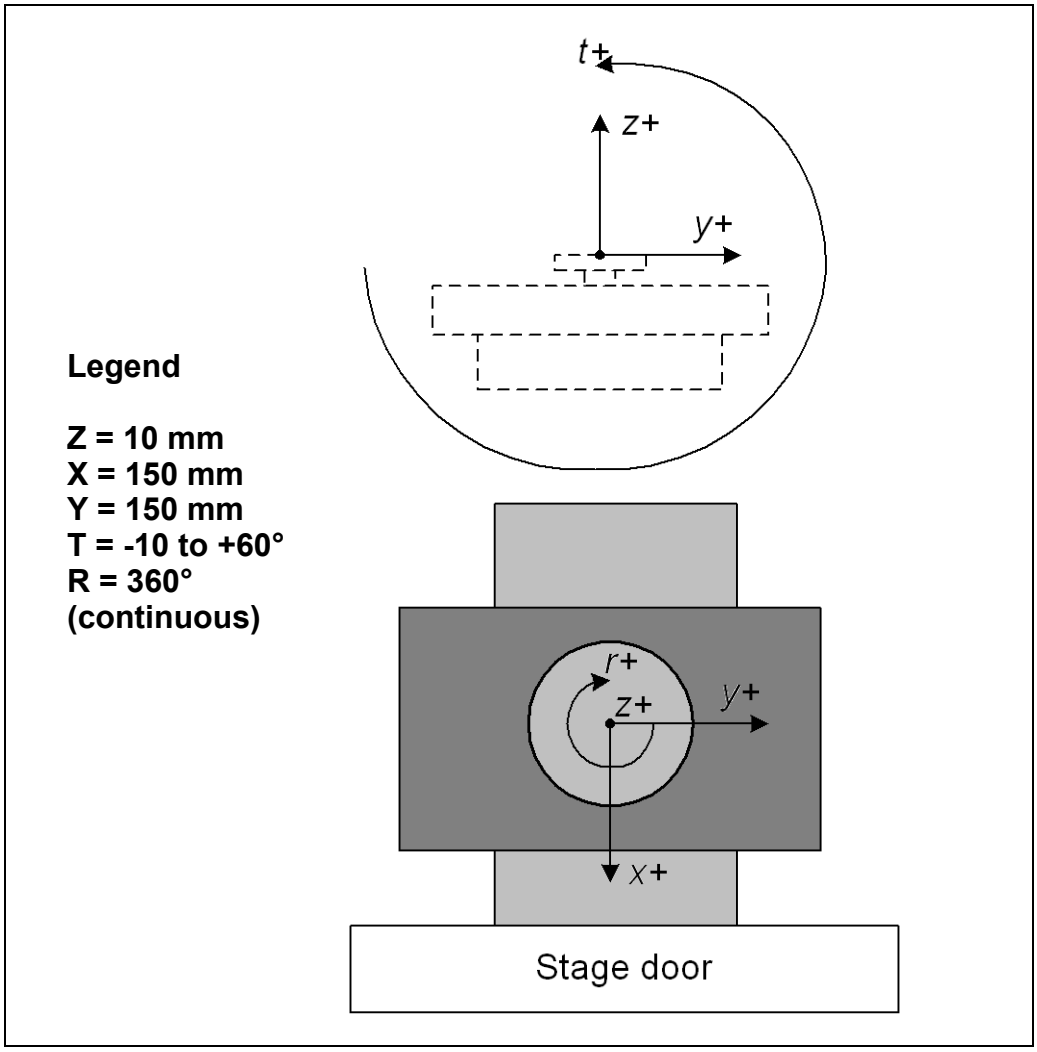


Stage movement

The stage can be tilted over 70°. The stage movement is motorized and is under software control.

Software controls for movement include the Shift, Get, Track and the Navigation Page functionality. You can access the Navigation Page by clicking on the appropriate icon above the pages.

FIGURE 6-6 NANOLAB 600 STAGE MOVEMENT



NOTE: By default, negative tilt is disabled by software interlock, as this may cause a conflict with insertion of gas injectors. To override the software interlock, contact your service engineer.

Using Z (height) adjustment

To set the specimen height and at the same time prevent any possibility that the specimen should touch the lens pole if the Z is increased can be done as follows:

- Load a specimen onto the specimen holder.
- Adjust the Z, so that the specimen is approximately 5 mm below the lens.
- Close the chamber, and pump down.

- When the beam is switched on focus the sample and click on the Z<->FWD button icon on the Tool bar. The FWD will be recognized by the system as the value of Z in the Coordinates tab of Stage in the Navigation page.
- Now the Z can be changed by the software interface control. For safety move the stage very cautiously when approaching less than 2 mm from the lens!

Using Clamp

The CLAMP function on the **Stage** menu provides an extra software-controlled lock. Use this lock when imaging at high magnifications (> 10,000 X).

Standard Sample Holders

The NanoLab 600 stage has 2 standard holders and an interface piece for clamp holders such as the UMB Holder (option).

The 200 and 600 stages have eucentricity and therefore need to have a Z prime position at a set height from the stage rotation head surface to bring the sample surface to a eucentric condition.

The eucentric holder is screwed into the center of the rotation head of the stage. When the stub with specimen is fitted, by tilting the stage, the position of tilt should be at the plane of the specimen. The specimen should not be of excessive height as this will not work.

FIGURE 6-7 600 STANDARD SAMPLE HOLDERS

Standard Single Sample Holder

Stage interface piece for UMB

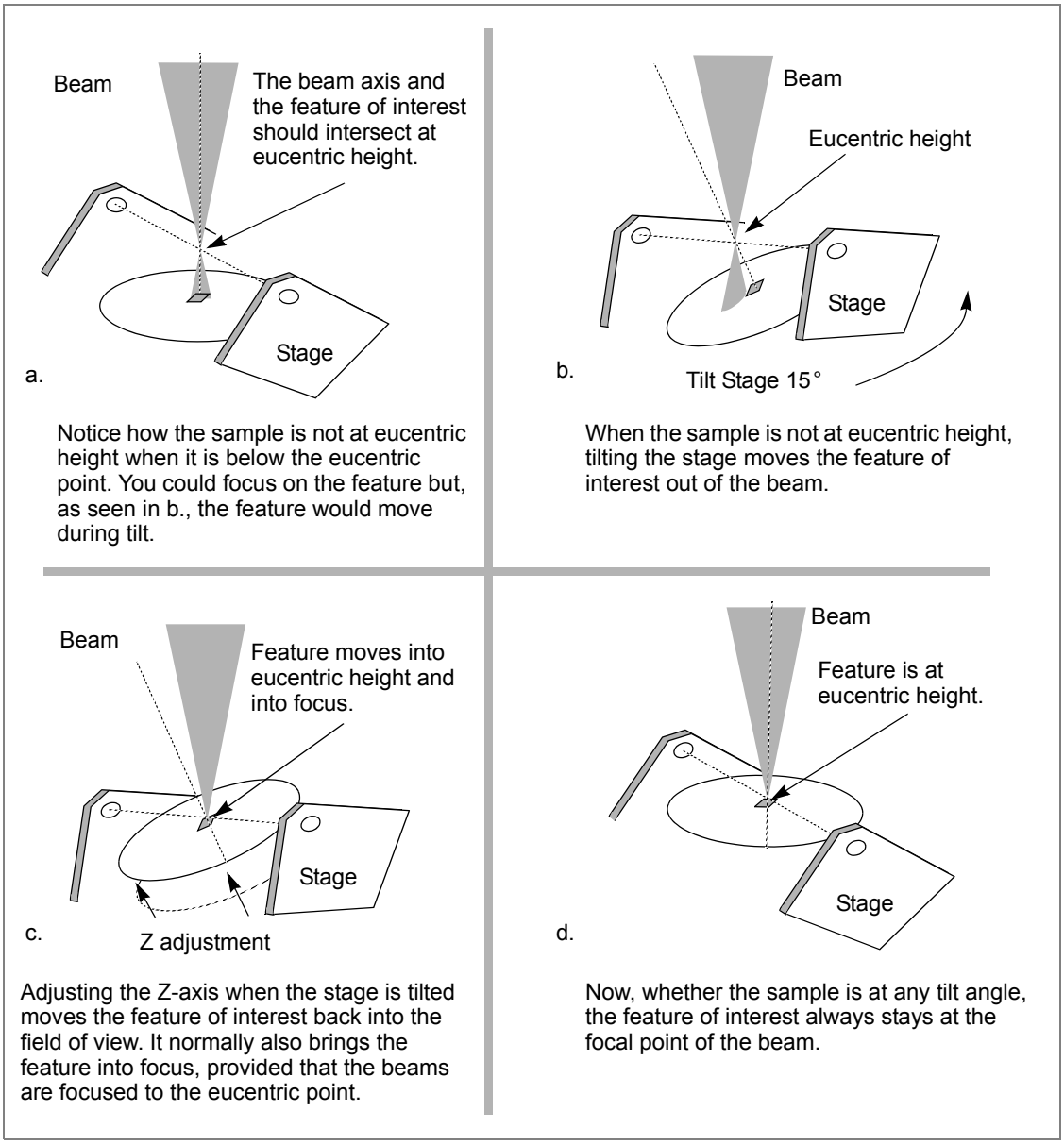
High Resolution Sample Holder

Finding the Eucentric Height

Establishing the eucentric height is an important part of setting up a sample for observation or modification. Eucentric height should be adjusted after loading any new samples as the load procedure clears all height information. When you have a feature of interest at eucentric height, you will be able to use the different Nova workstation components such as the GIS and EDX, in a safe and optimal way. The eucentric point is where the stage tilt axis and the ion and electron beam axes intersect. At this point, no matter which direction the stage is tilted or rotated, the feature of interest remains focused and almost no image displacement occurs.

Finding eucentric height on the workstation is the process of positioning the sample so it is at the eucentric point. The following figure is an overview of this process.

FIGURE 6-8 UNDERSTANDING EUCENTRIC HEIGHT


Beam
The beam axis and the feature of interest should intersect at eucentric height.
Stage
a.
Notice how the sample is not at eucentric height when it is below the eucentric point. You could focus on the feature but, as seen in b., the feature would move during tilt.
Beam
Eucentric height
Stage
b.
Tilt Stage 15°
When the sample is not at eucentric height, tilting the stage moves the feature of interest out of the beam.
Beam
Feature moves into eucentric height and into focus.
Stage
c.
Z adjustment
Adjusting the Z-axis when the stage is tilted moves the feature of interest back into the field of view. It normally also brings the feature into focus, provided that the beams are focused to the eucentric point.
Beam
Feature is at eucentric height.
Stage
d.
Now, whether the sample is at any tilt angle, the feature of interest always stays at the focal point of the beam.

Finding Eucentric Height

For many samples other than wafers, or for greatest accuracy, use the following manual procedure to obtain eucentric height. Eucentric height requires an E-Beam working distance of approximately 5 mm.

TABLE 6-1 FINDING EUCENTRIC HEIGHT MANUALLY

Step	Action
1	On the **Stage** menu, select ZERO BEAM SHIFT.
2	If the small yellow cross is not already displayed in the center of the screen, press **Shift + F5** to display it.
3	Make SEM image live.
4	Set stage tilt to 0°.
5	Focus using MUI or right-mouse button.
6	Couple" Z to FWD.
7	Bring the stage to 5 mm WD.
8	At 1000x magnification, find a distinct feature and center it under the yellow cross by moving the stage.
9	Tilt stage to 7°. Using Z-control bring the feature back under the cross.
10	Tilt back to 0°. The feature should not shift significantly. If the shift is > 5-10 µm repeat steps 8 to 10.
11	Tilt to 52° and verify that the feature stays in the center of the screen.

Aligning Beams at the Eucentric Height

This procedure assumes that your stage is at eucentric height and that both beams are on.

TABLE 6-2 ALIGNING BOTH BEAMS

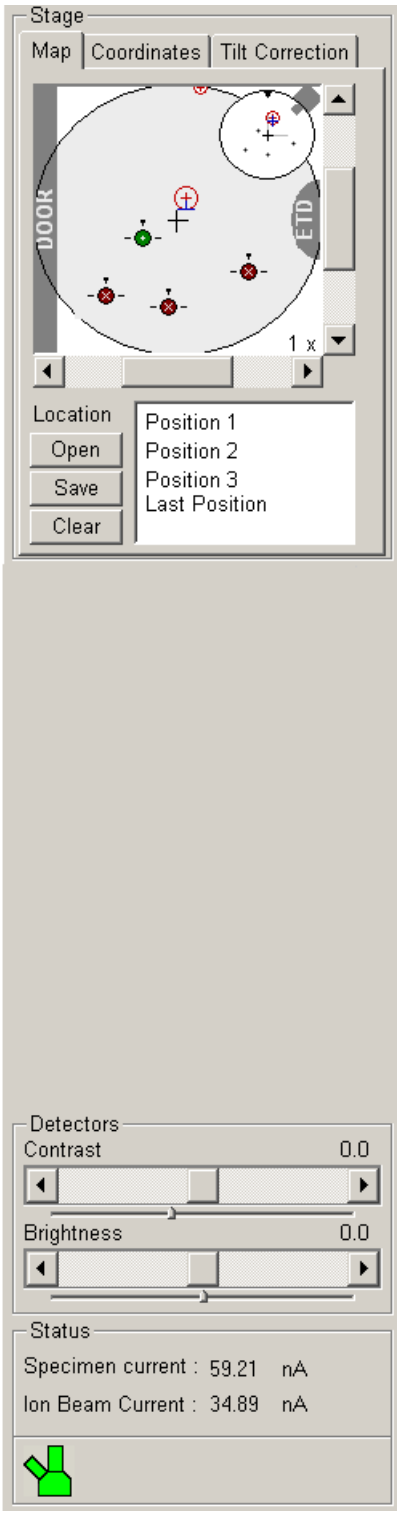
Step	Action
1	Click on the **Electron Beam** icon in the **Tool Bar**.
2	Tilt the stage to 52°.
3	While imaging with the E-Beam, and at 1000x magnification, find a distinct feature and move it under the red cross by moving the stage.
4	Click on the **Ion Beam** icon in the **Tool Bar**.

TABLE 6-2 ALIGNING BOTH BEAMS

Step	Action
5	Using image shift, bring the same feature back under the red cross.
6	If you cannot align the two images, recheck the eucentric height with the manual procedure.

NOTE: After aligning the two beams, avoid using beam shift with the ion and electron beams.

Software Stage Functions



The **Navigation Page** has a number of modules including Stage. The Stage module controls movements of the stage to locate the positioning of the specimen by reference to coordinated points.

Stage

The Stage module consists of 3 planes at present, MAP, COORDINATES and TILT CORRECTION. These are accessed by horizontal tabs at the top of the module.

Map tab

The MAP tab displays a LOCATION list box for storing and selecting positions store on the map. The stage maximum cover is displayed as a large rectangular area, known as the MAP, with an inscribed circle displaying a center axis cross. All positions to be located and stored will be shown on this large circle. In the top right corner there is another smaller circle known as the RADARVIEW, and is the true rotational condition of the stage at any time.

Radarview

The small circle in the top right of the stage area relates to the rotation position of the stage at one-time. By holding the left mouse button down on the black triangle on the perimeter of the circle and moving it round to another angle position the stage will follow the action promoted on release of the mouse button. The large circle remains in the same state to represent true X and Y directions. All positions that incurred rotation of the stage in their stored locations Maps will display rotation condition in the radar view when restored to the current position. Orientation is seen by the update of the small triangle and the ‘clock hand’ lines in the radar view circle.

Location

When LOCATION is expanded it shows the list of positions with a scroll facility. The one selected becomes the current active position. When a position is selected it highlights in the list and also on the map as a point with a red circle.

Open

When stored positions are required from a stored file clicking on the OPEN button will open the import Open dialog to import a stage file.

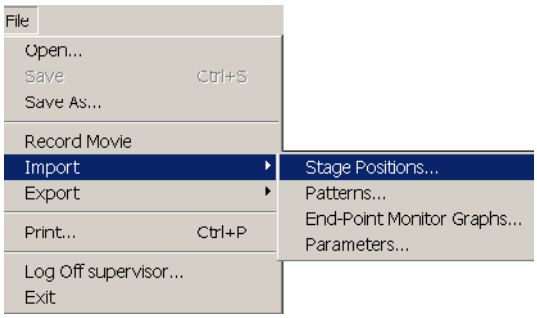
Save

To store positions to a file clicking on the SAVE button will open the export Save dialog to export a stage file.

Clear

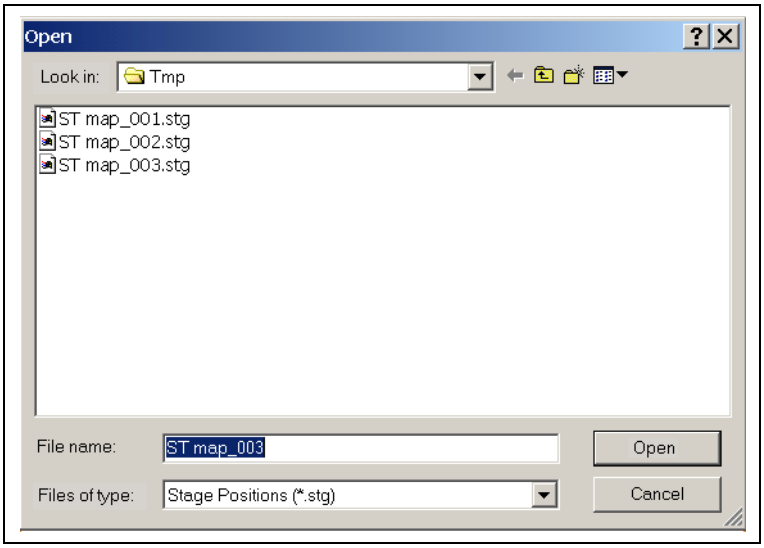
Clicking on this button clears the current LOCATION list and MAP.

Import

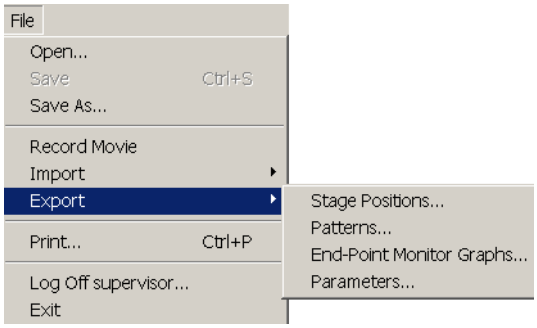


Open the **File** menu and click on the IMPORT item to import STAGE POSITIONS as a Map file. An OPEN dialog appears with the list of Map files. Select the Map file required and click on OPEN. The Map file is then loaded into the Stage navigation system and the list of positions update in the LOCATION list.

FIGURE 6-9 IMPORT DIALOG

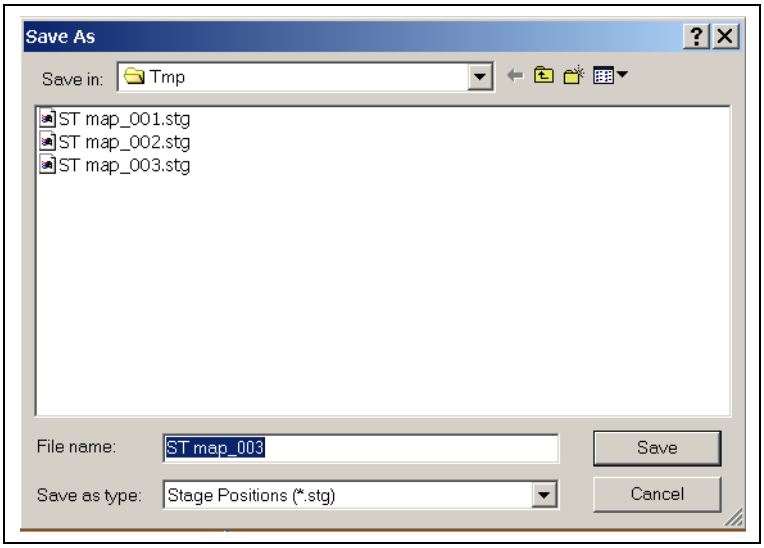


Export



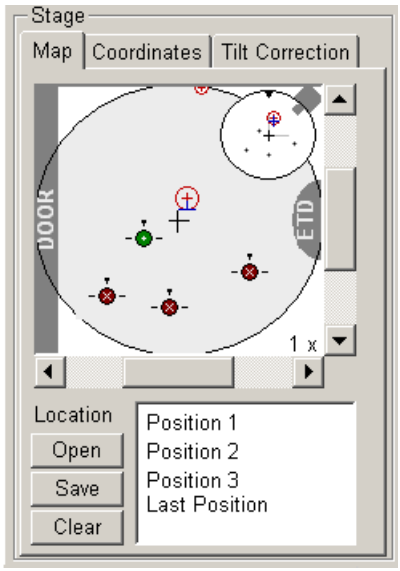
Open the **File** menu and click on the EXPORT item STAGE POSITIONS to save a Map file. A SAVE AS dialog appears with the list of Map files. Type or Select the Map file name required and click on SAVE. The positions in the LOCATION list are then saved as a Map file.

FIGURE 6-10 EXPORT DIALOG



More information on the relationship of MAP and LOCATION is described in the following sections.

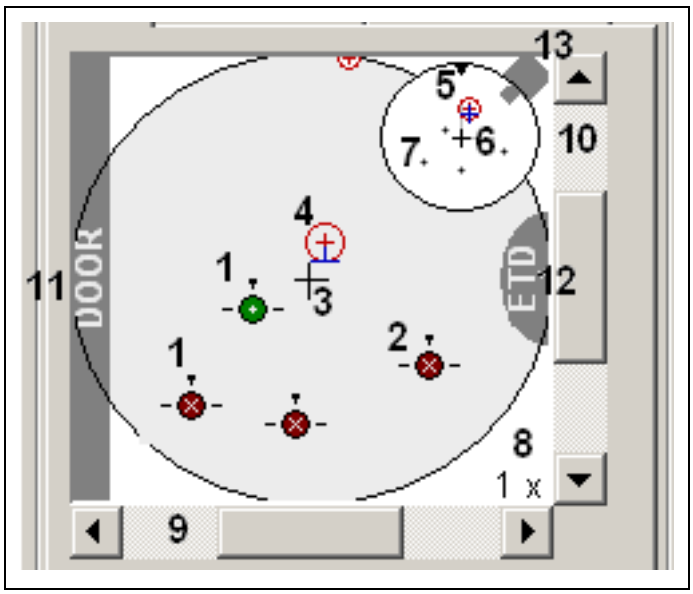
Map Elements



Map Area

The MAP area represents the total range of the stage in X and Y. In the locatable area representative positions can be specimen positions or just positions on a single specimen. They are only numbered, by default or intent, in the drop down list box LOCATION and not on the MAP area. The positions and other elements are shown in the MAP area.

FIGURE 6-11 MAP ELEMENTS



The numbers on the figure above are represented in the list below with association to their function.

TABLE 6-3 MAP ELEMENT FUNCTIONS

No.	Function
1	White cross with red background in black circle. A stored location in the LOCATION list. Without rotation. White vertical cross on a green background indicates that a stored position is highlighted in the LOCATION list
2	White cross with red background in black circle. A stored location in the LOCATION list. With rotation noted by position of the black key.
3	Black cross. Mechanical stage center.
4	Blue cross with red circled cross. The blue cross is a new location not stored and the red circled cross is the current targeted position.

TABLE 6-3 MAP ELEMENT FUNCTIONS

No.	Function
5	Black triangle. The moveable rotation angle positioner.
6	Gray 'clock hands'. Denote rotation position as 5.
7	Gray crosses. Stored positions as on the map.
8	1x to 100x. Magnification factor of the map.
9	X slider to move the mapped area in a X (stage) direction at different zoomed out magnifications.
10	Y slider to move the mapped area in a Y (stage) direction at different zoomed out magnifications.

Map dialog

The MAP dialog can be accessed by clicking with the right mouse button in the map area.The different stage sizes will be represented by a different sized shaded circle at default 1x.

Add current stage position

Clicking with the mouse left button anywhere on this circle area will present a blue cross. Then clicking on the right mouse button will give a drop down menu overlaying the **Stage** module to invite the adding of the Blue cross position to the LOCATION list. By clicking on 'ADD CURRENT STAGE POSITION' this function is carried out. In this way the list can be compiled for particular applications. The blue cross turns black and receives a black circle around it. The end functionality is the same as the ADD button.

Update to current stage position

Clicking on this stores the (edited) position under the currently selected name. The end functionality is the same as the UPDATE button.

Remove selected position

Clicking on this in the dialog list will remove position from the map and the highlighted label in the location list. The end functionality is the same as the REMOVE button.

Center view

In the same menu clicking on the item CENTER VIEW will bring the location center to the center of view rather than the stage axial center.

Auto center on target

When using the 'MAGNIFICATION' (Zoom) function the location that is the present active location can remains in the center of view relative to the Map area if 'AUTO CENTER ON TARGET' is clicked ON in the fixed drop down menu. ON is represented as a tick mark.

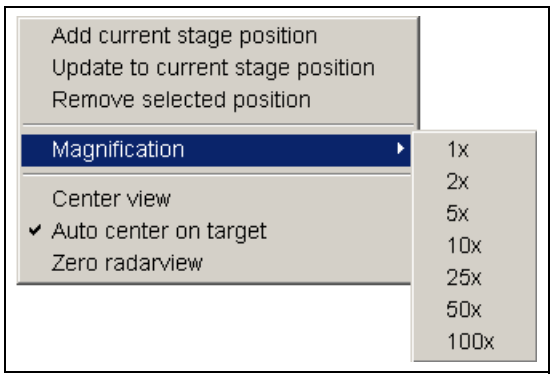
Zero radarview

Clicking on ZERO RADAR VIEW will bring the radar view circle to zero position (12 o'clock), and rotate the stage mechanically to the home condition for rotation movement only.

Magnification (Zoom)

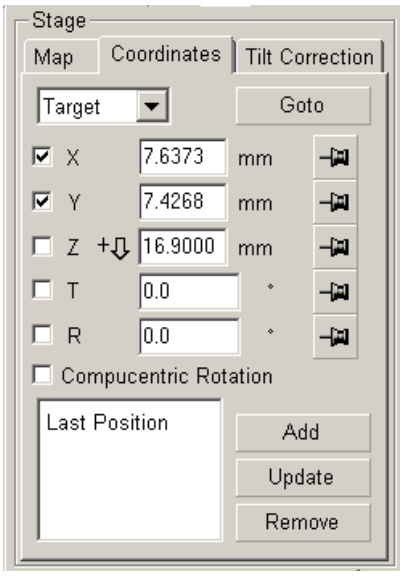
Clicking on the right mouse button, when over the Map area, will give the fixed drop down menu for MAGNIFICATION (ZOOM). By clicking on the item labelled 'MAGNIFICATION' the magnification factor of the MAP area can be selected from a further drop down menu.

FIGURE 6-12 MAP MAGNIFICATION (ZOOM)



The resulting multiple value is seen in the bottom right-hand corner of the map area. Scroll bars are present to move over the whole map area in zoomed condition.

Coordinates Tab



Coordinates Tab displays a numerical layout for X, Y, Z, R and T. Position can be selected in a similar LOCATION list. LAST POSITION is always present in the LOCATION list.

X, Y, Z, R, T

Five editable text boxes are available for X, Y, Z, R and T, these are separately editable or can be filled from the selection made at the LOCATION list. When any of the editable boxes are written to the tick box to the left of the parameter automatically checks to show that the value entered is a target value. This functions irrespective of coordinate status (Actual/Target/Relative).

Actual Mode

This mode is used by the LAST POSITION, which is displayed in the edit boxes. The ADD, UPDATE and REMOVE buttons are active. The GOTO button is inactive.

Target Mode

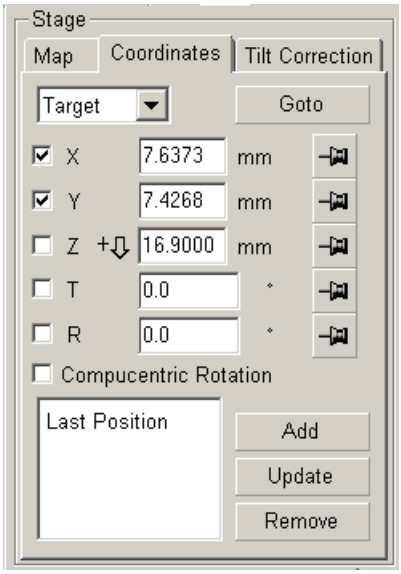
This mode becomes active when any stored POSITION is clicked on in the LOCATION list. The GOTO button also becomes active, when clicked on the stage will drive to that location. The ADD, UPDATE, REMOVE and GOTO buttons are active.

Relative Mode

This mode is used to make repetitive or equal movements in relation to a key point or points. The coordinates can be in known units or

more often in user units defined from the setup found in the **Stage** menu. The item 'DEFINE USER UNITS' sets up the coordinates and the item 'USER UNITS' switches between known units and user units. When RELATIVE mode is in operation the ADD, UPDATE, REMOVE and GOTO buttons are active.

Editing a coordinate



When in Actual mode:

- With the LAST POSITION selected will de-select the current position (so no position is selected at all), will change the mode to TARGET MODE and will disable the UPDATE button. The GOTO button is active. Boxes become ticked.
- To update any other POSITION enter new values in any of the edit boxes. This will change the mode to TARGET MODE and will enable the UPDATE button (the position remains selected). Boxes become ticked.
- if no position is selected the edit boxes can be filled and the mode will change to TARGET MODE. The GOTO button is active. boxes become ticked

When in Relative mode:

- Editing a coordinate will change the mode to TARGET MODE. The GOTO button becomes active. Boxes become ticked.

Locks

These are software locks to prevent inadvertent movement of any or all axis during particular applications. Default is unlocked. The edit boxes for axes that are locked are grayed out and cannot be entered or updated. Axes that are locked do not move when the GOTO button is activated. When any or all of the axes are locked the lock icon in **Status** displays a closed lock.

Units of measure

The units of measure (to the right of the position edit boxes) follow the **Units** setting in the **Preferences** dialog, unless **User Units** is active (Stage menu), then **UU** will be displayed for X and Y).

Location

When expanded it shows the list of positions with a scroll facility. The one selected becomes the current active position. To move to that position requires clicking on the GOTO button.

The behaviour is as follows:

- Clicking a non-selected item will select it, which causes the corresponding position to be displayed in the edit boxes.
- Clicking a position when it is already selected will start in-line editing of the item's name (renaming it). Pressing the **Enter key** or clicking a different item confirms the new name. If the new name is already in the list a warning is given and the editing is resumed (with the incorrect name). When the user presses the **Escape key** the old name is restored, cancelling the renaming.
- Double-clicking an item is the same as clicking it and then pressing GOTO; it immediately moves the stage to that position.

- The list always contains the LAST POSITION. Selecting LAST POSITION will display the last stage position moved to and changes to this position can be updated as long as the LAST POSITION item is selected.
- When the stage coordinates are edited manually the selected position will be de-selected if it is the LAST POSITION, while for any other position the UPDATE button will become enabled (and the item will remain selected).

GoTo

Pressing the GOTO button will cause the stage to go to the currently displayed position (in ACTUAL mode) or to move relative to the current position (in RELATIVE mode).

- The Goto button is disabled if the LAST POSITION is selected in the LOCATION list; it is enabled in all other cases.

Add

Pressing the ADD button will create a new entry in the LOCATION list, using the currently displayed position.

- The Add button is disabled in RELATIVE mode (you cannot store a relative position), and is enabled in ACTUAL mode.
- The new entry is called POSITION x, where x is 1, 2, 3, etc. If an item with the new x already exists the value is incremental until a unique name is obtained. The user can rename the new entry, see LOCATION list.

Update

The UPDATE button stores the (edited) position under the currently selected name.

- The Update button is disabled in RELATIVE mode.
- In ACTUAL mode it is enabled only when a POSITION is selected in the LOCATION list.
- Pressing the UPDATE button will store the coordinates under the currently selected position (overwriting the old position), without asking for confirmation.

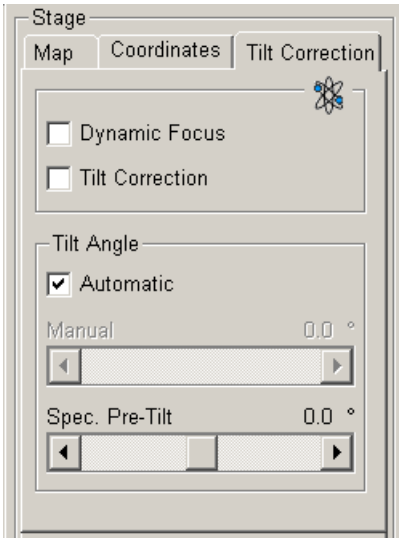
Remove

The REMOVE button deletes the currently selected item in the LOCATION list.

- It is enabled when a position is selected in the Location List, but only if this position is not LAST POSITION.

Compucentric Rotation

If compucentric rotation is ticked the stage will operate to the computer defined centre of rotation and not the physical rotation centre.



Tilt Correction Tab

The Tilt Correction Tab contains correction features to the tilted image. When these are ticked in the boxes they become active.

Dynamic Focus

Click in the checkbox to switch DYNAMIC FOCUS on or off. When it is on, the scan slowly proceeds from top to bottom and the focus point is automatically changed according to the positive tilt of the specimen. The focus should be sharpest in the middle of the image. DYNAMIC FOCUS can only be used with scan rotation at zero. You must enter SPECIMEN PRE-TILT for the calculations to be accurate. DYNAMIC FOCUS can be used for a strongly tilted specimen (either by the specimen surface itself or by stage tilt), when the depth of focus is not sufficient. It results in an image with overall sharpness.The DYNAMIC FOCUS is usually used usually at low magnification.

Tilt Correction

Because the image is a two-dimensional representation of a three-dimensional object, certain projection distortions occur. The more highly tilted the specimen is, the more foreshortened its image will be. Applying a tilt correction will compensate for foreshortening in one direction on a flat specimen at a known tilt angle (80° range) and when the tilt axis is parallel to the scan line.

TILT CORRECTION can only be used with scan rotation at zero. You must enter SPECIMEN PRE-TILT for the calculations to be accurate. For example, a square grid image will appear rectangular when you tilt the specimen. Applying TILT CORRECTION will correct the aspect ratio and restore the square appearance.

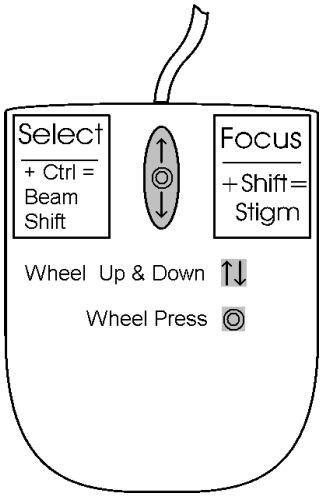
Tilt Angle

Use automatic if the correction angle to be used is the same as the stage tilt angle (including Specimen pre-tilt, see below). Use Manual to manually enter the angle for which the dynamic focus and tilt correction compensate for.

Specimen Pre-tilt

Use this adjuster only in conjunction with DYNAMIC FOCUS and, or TILT CORRECTION. Enter the specimen tilt angle on the slider and then tick the necessary checkbox. If Tilt mode is selected to be Manual (see above), the slider value now indicates the absolute angle that should be used for the compensations (regardless of the actual stage tilt angle, or specimen pretilt).

How to make Stage Movements



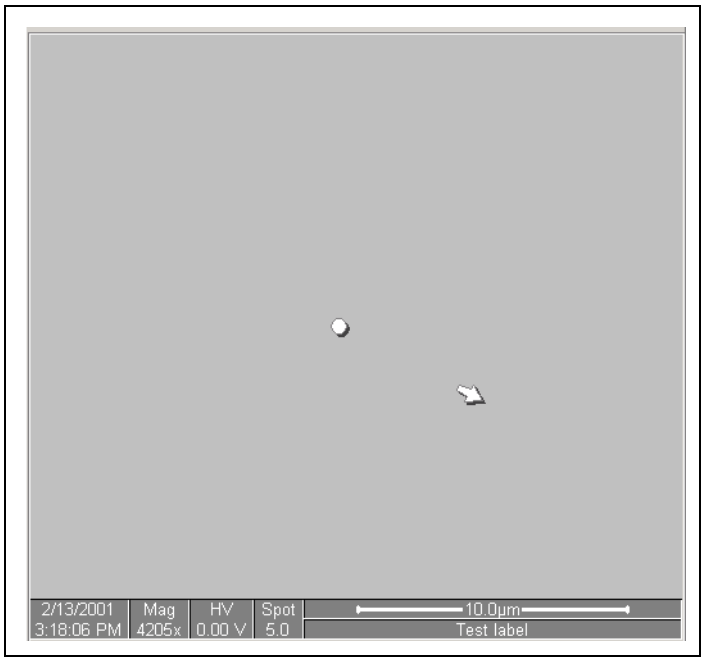
Track

The **Track** function allows continuous directional movement of the stage with variable speed. The speed range is coupled to the magnification and selectable within certain limits.

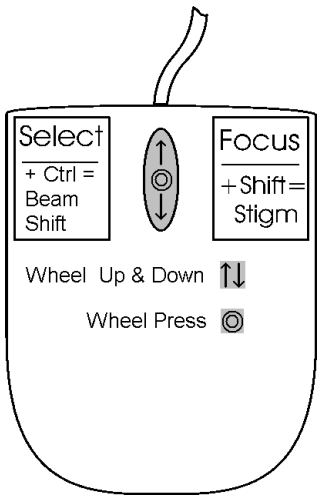
Select the Track function by pressing on the **Mouse Wheel** while in an active Quad (1 - 3) or on full screen. A Yellow enhanced **Dot** and **Arrow** appear onscreen. The Dot will occur where the mouse command cursor was when the wheel was pressed and the Arrow will denote the direction to move. The speed will depend on the distance the Arrow is separated from the Dot. The direction can be changed by moving the mouse in a circular motion to obtain the correct traverse.

The movement axis center will depend on the initial positioning of the command cursor, which can be at any position on the image. Moving away from the Dot with the Arrow increases the stage speed; moving toward the Dot decreases stage speed.The direction of movement is always toward the central Dot along a straight line. You can move the cursor around on the field of view; direction and speed change accordingly. When you are done release the mouse wheel and the action will stop, Dot and Arrow disappear from the image.

FIGURE 6-13 TRACK FUNCTION



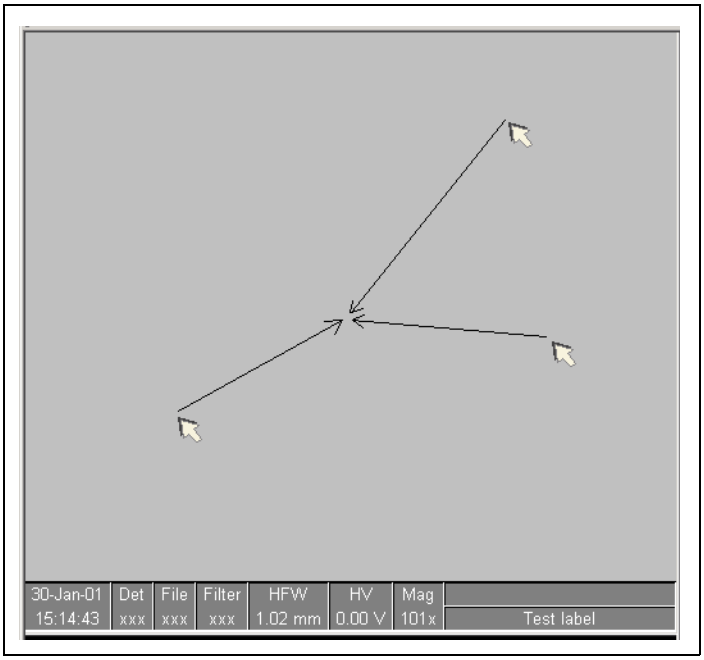
In Quad 4 (CCD mode) the same function activates the Z movement. With the wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. This activity can be seen live in the CCD Quad 4 window. Representation of direction is indicated by a centered yellow arrow, either pointing up or down either side of a 10mm bar indication point.



Get

When you select an image object with the cursor and double-click the left mouse button, **Get** brings that detail to the center of the screen using the stage movement. Stage movement will center the object by mechanical movement of the stage and therefore will be limited to a useable range of magnification (lower magn). The maximum range for successive Get operations equals the range of the stage movement.

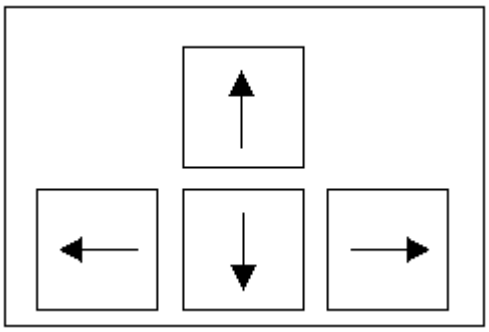
FIGURE 6-14 GET FUNCTION

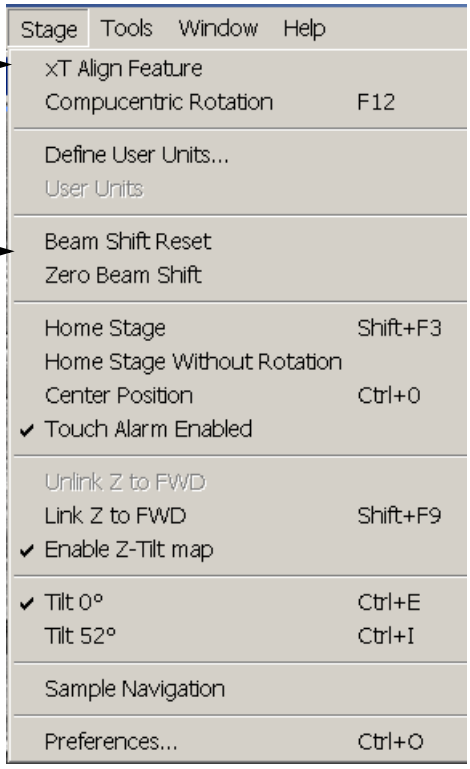


Stage Frame Shift

The stage can be moved approximately 80% of the field of view in any direction by clicking on the appropriate **Arrow key** on the keyboard. The maximum range for successive Frame Shift operations equals the range of the stage movement.

FIGURE 6-15 ARROW KEYS FOR STAGE FRAME SHIFT





Beam Shift Reset

Use this function to begin the BEAM SHIFT RESET procedure to zero beam shift and move the feature to the center of the field of view with the stage.

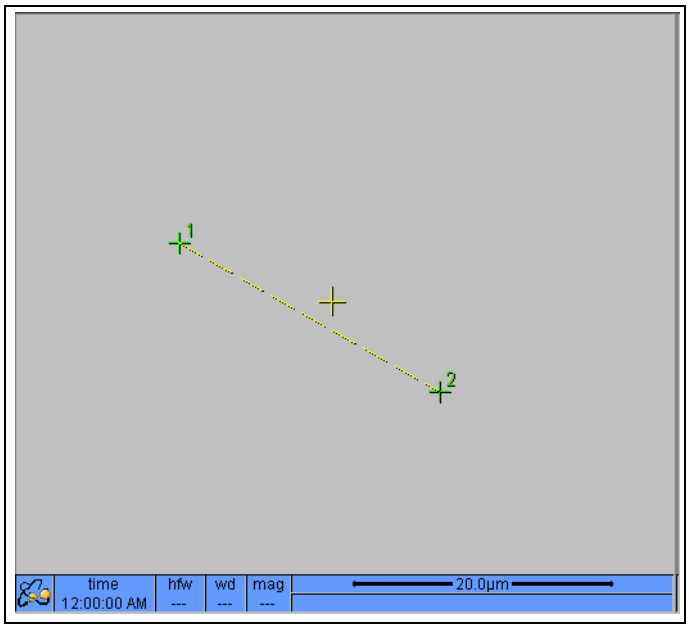
Zero Beam Shift

When beam shift has reached maximum limits, choose ZERO BEAM SHIFT to restore X and Y beam shifts to zero values. The computer beeps when maximum limits are reached.

xT Align Feature

Designed specifically for long features or when there is need to navigated along a feature that extends off the screen at the magnification require for observation. ALIGN FEATURE applies the de-skew process across the entire length bringing the long feature either to the chosen horizontal or vertical axis to make it easier to navigate. This can be performed at any point within the stage field limits and takes into account the off-set for rotation by computer programming of the stage. Point 1 is first located and then point 2. When this occurs point 2 is not fixed but subtends point 1 with an elastic cord until the left mouse button is released. At this position point 2 is located. The longer distance involved results in greater accuracy.

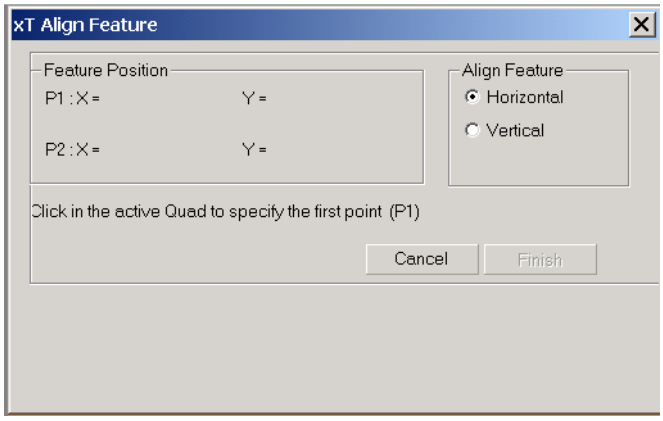
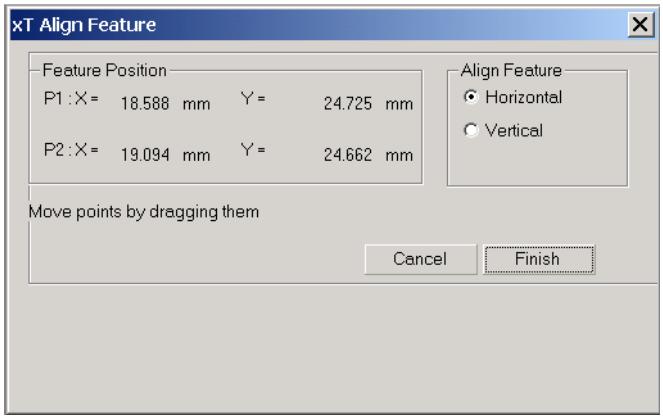
FIGURE 6-16 XT ALIGN FEATURE



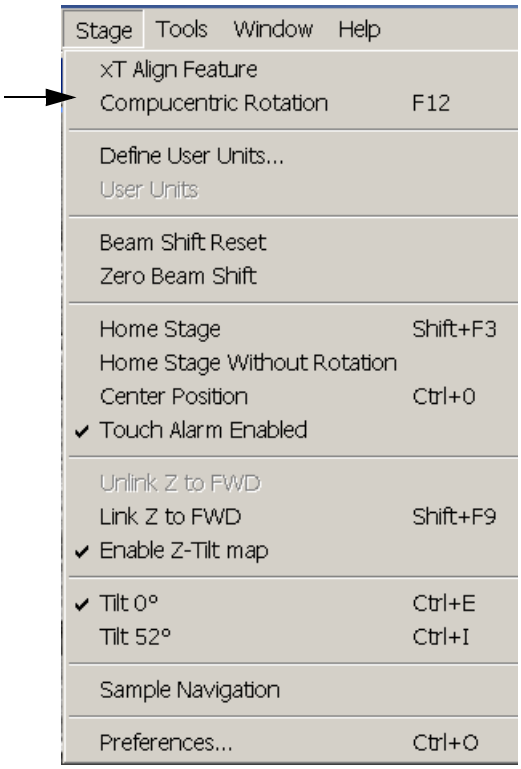
ALIGN FEATURE is designed to work best at the eucentric height of 5mm. The Z to FWD should be corrected to the eucentric height as described in the section ‘Setting Eucentric Height’.

Because the stage makes movements by software control care should be taken that there are no significantly higher obstacles on the sample plane set at the eucentric height, as these may interfere with equipment under the lens.

TABLE 6-4 SETTING ALIGN FEATURE

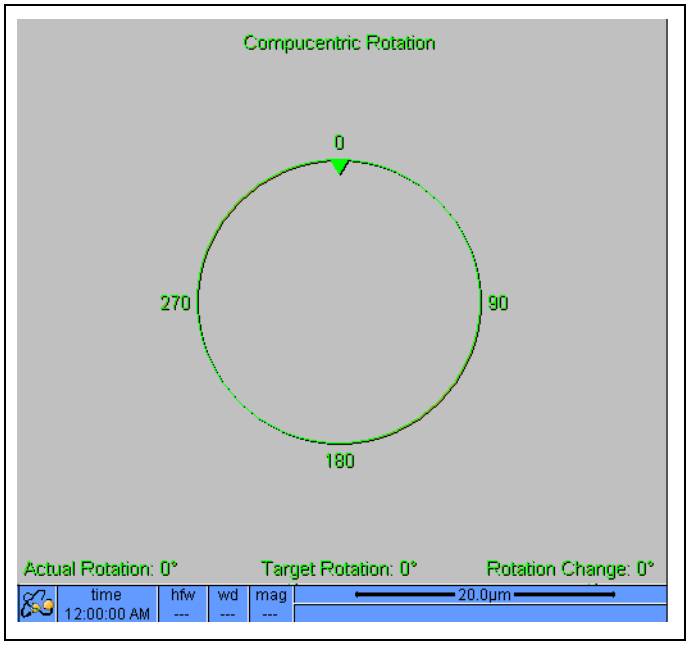
Step	Action
1	Select a long feature on the sample.
2	Click on ALIGN FEATURE from the **Stage** menu. Follow the directions in the dialog box that appears and choose either Horizontal or Vertical that relates to the orientation needed on the sample. 
3	Click with the left mouse button on the first point somewhere along the feature. The coordinates are updated in the dialog. Now drag the line out from the first point to the second point using the mouse. The second coordinates update continuously till released by clicking again. Click on FINISH to end the selection and for the program to orientate the feature to the selected horizontal or vertical. Click on CANCEL to the function. 

Compucentric Rotation



Clicking on COMPUCENTRIC ROTATION in the **Stage** menu places a green circle in the active quad. At a point on the perimeter of the green circle is a green triangle which denotes, by its position, the angle orientation of the sample relative to its original position when placed on the stage. To start with this will be at 12 o'clock. By keeping the left mouse button down on the green triangle it can be moved around the circle to chose a new orientation of the sample relative to the detection position. On release of the left mouse button the computer software updates the position orientation and offset from the mechanical stage center to deliver the same object center but rotated to the angle selected. This creates a different direction of illumination for the sample while keeping the object of interest in the center of the display area. With the sample at the eucentric height this can be performed at any position on the sample irrespective of the mechanical stage center. Clicking on or close to the numbered angles around the perimeter of the circle will cause the stage to drive to that angle and the green triangle will update on screen.

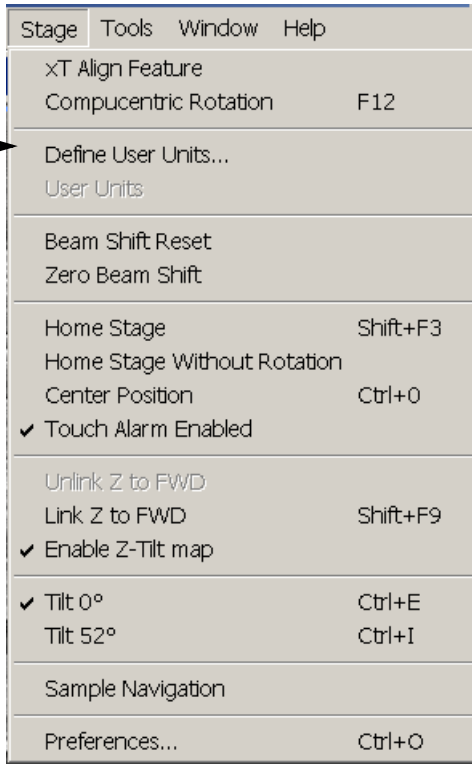
FIGURE 6-17 COMPUCENTRIC ROTATION



The read-out positions displayed at the bottom of the Quad provide information on the 'ACTUAL ROTATION' (original position in degrees), the 'TARGET ROTATION' (the selected position in degrees) and the 'ROTATION CHANGE' (the difference in degrees of rotation). The screen dialog can also be activated by selecting **F12** on the keyboard

Compucentric Rotation can also be activated from the **Navigation** page.

Define User Units



DEFINE USER UNITS associates stage points with user-defined points to set up a mapping between stage and user coordinate system. After that, the computer uses these specimen coordinates rather than stage coordinates for positioning.

For example, a die of an integrated circuit has its own coordinate system. If you choose a 0,0 position, you can drive the stage relative to that position using your own coordinate system. These are expressed in User Unit (UU) coordinates, which may be microns, multiples or fractions of microns, etc. Coordination of the stage can be anchored to either 1, 2 or 3 points depending on the sample management or application.

Choose points that are not in a straight line, for example, at the corners of a die or the edges of an area or wafer. You can align up to three points, when you obtain the greatest accuracy.

The following procedure sets up the 1 - 3 Point alignment for any given sample where repeated structures are checked.

TABLE 6-5 DEFINE USER UNITS

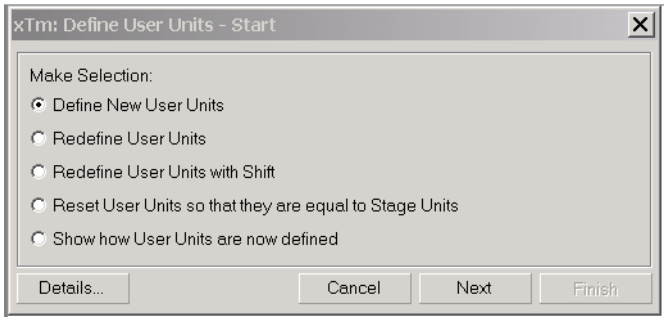
Step	Action
1	Select a feature on the sample surface and bring it into the field of view at a magnification so that it relates to other structures (not too high magnification).
2	Click on DEFINE USER UNITS in the **Stage** menu. A dialog appears as follows.  Select from the **Start** dialog the DEFINE NEW USER UNITS process by clicking on the radio button. Click on the NEXT button.

TABLE 6-5 DEFINE USER UNITS

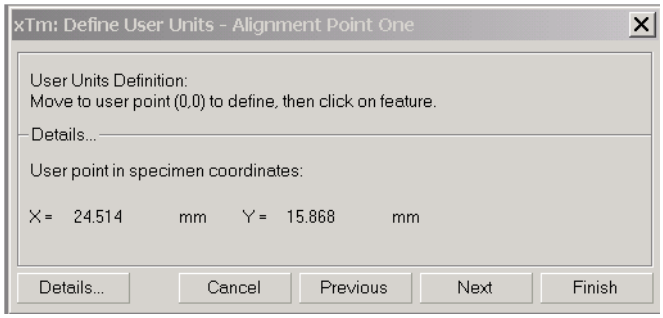
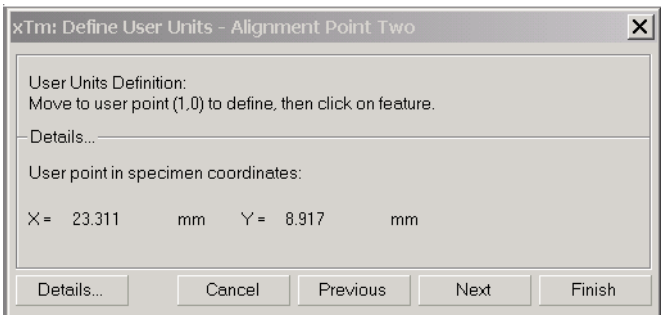
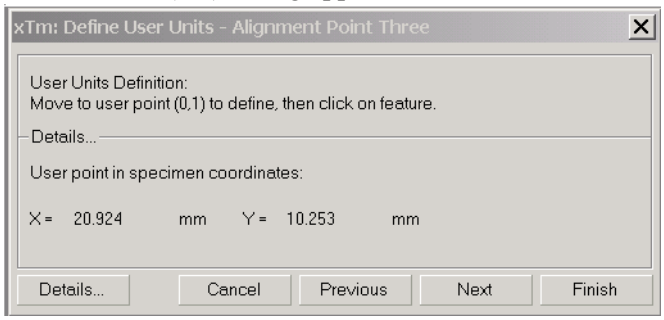
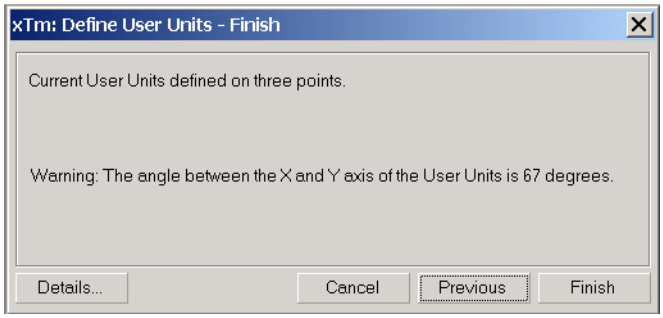
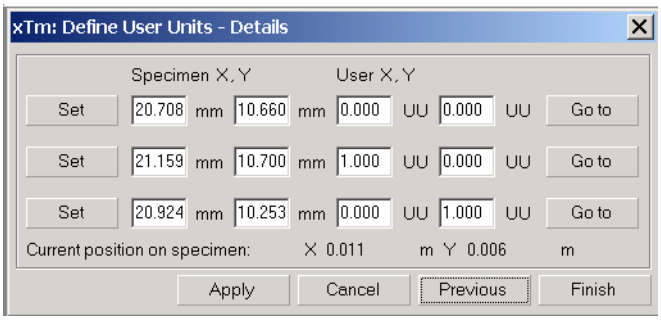
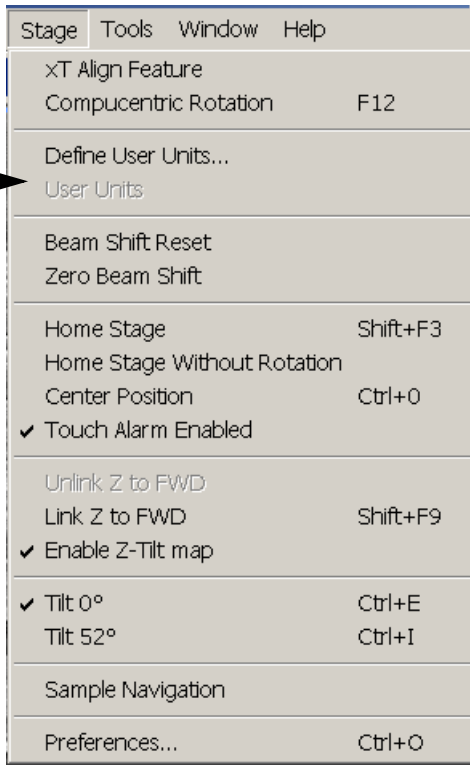
3	The **Alignment Point One** (0,0) dialog appears.  Follow the instruction in the dialog to move to a point and click on it with the left mouse button. The coordinates of that point (0,0) will appear next to the USER X and USER Y readout positions in the Details... section of the dialog. Choose the next step either: • Click on the PREVIOUS button to return to the previous dialog. • Click on FINISH to end the alignment at one Point. • Click on the NEXT button to continue to two points • Click on the CANCEL button to exit the procedure.
4	After clicking on the NEXT button the **Alignment Point Two** (1,0) dialog appears.  Repeat the procedure selecting and clicking on a new location point. The User read-out positions will show the coordinates for the new Point Two location. Choose the next step from the bottom line of buttons as in Step 3. To continue click on the NEXT button

TABLE 6-5 DEFINE USER UNITS

5	After clicking on the NEXT button the **Alignment Point Three** (0,1) dialog appears.  Repeat the process as in Step 4.
6	After clicking on the NEXT button a confirmation dialog appears as follows. 
7	By clicking on the DETAILS button at any stage, either 1, 2 or 3 Points, will cause a display of the resultant coordinates.  This concludes **Define User Units**

There are a number of choices on the **Define User Unit** start dialog. These are listed here to explain their functionality:

- DEFINE NEW USER UNITS - as explained in this chapter.
- REDEFINE USER UNITS - for changing / updating User Units.
- REDEFINE USER UNITS WITH SHIFT - for changing / updating with Beam Shift.
- SHOW HOW USER UNITS ARE NOW DEFINED - Displays the current details.



User Units

To activate USER UNITS as the basis of the stage coordination system, click on USER UNITS in the **Stage** menu. A tick mark will appear next to the label. The stage coordinate system will revert to the last defined user unit configuration for 1, 2 or 3 Point Alignment. From this point on the stage can operate in ABSOLUTE or RELATIVE mode with User Units to perform specific movements.

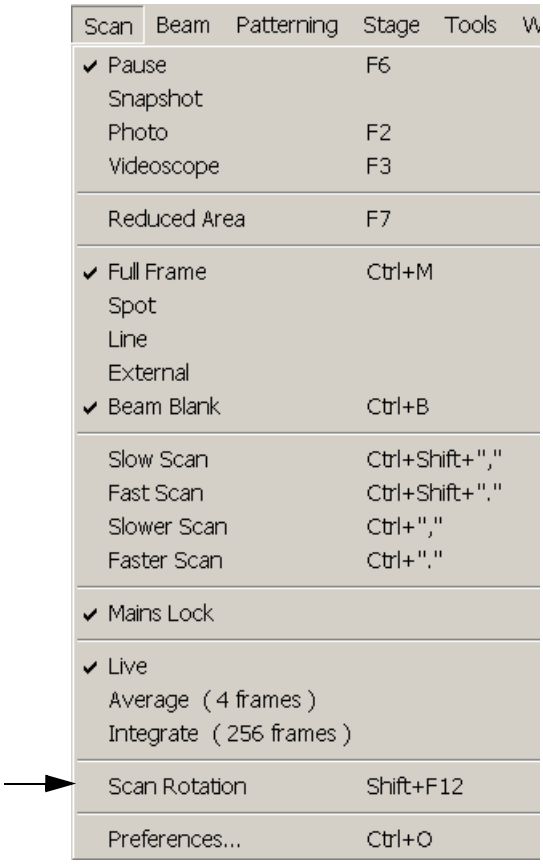
Using 1-, 2- or 3- Point Alignments

The following table shows the different uses between alignment types.

TABLE 6-6 ALIGNMENT TYPE DIFFERENCES

Use	1-Point Alignment	2-Point Alignment	3-Point Alignment
Major Use	Aligning to a new set of coordinates directly offset from the existing ones	Aligning the stage axes with the sample X-Y orientation to correct for any skew and overall scale	Most general alignment. Re-scaling to nonstandard units on CAD dies or RAM arrays; correcting for any skew
Change in Scale	None	Scales the axes together	X can be scaled differently from Y
Change in Orientation	None	Rotates both axes with a fixed 90° angle between axes	X and Y orientations can be non-orthogonal and can be mirror-imaged

Stage Related Functions



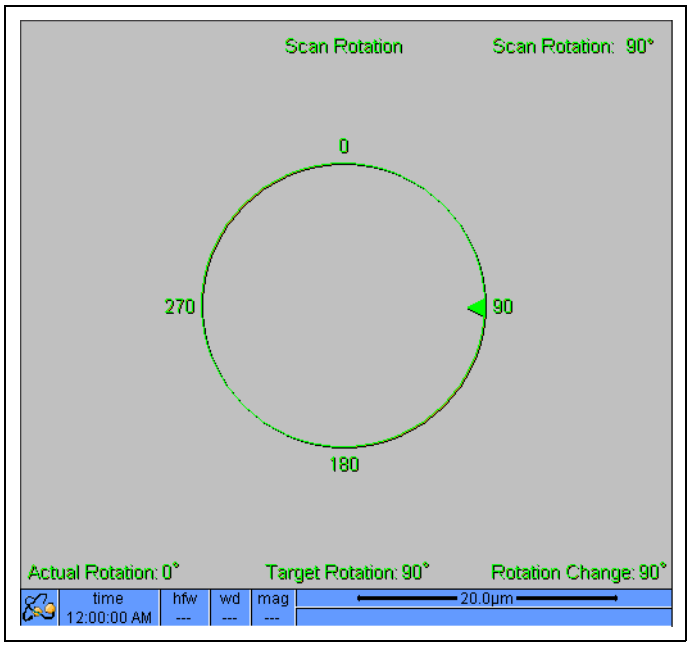
Scan Rotation

This button is used activate the onscreen tool to rotate the scan and align the image. It has no effect on the stage movements and is solely a scan coil function but is used to orientate the image relative to mechanical rotation and detector direction.

Using Scan Rotation

Clicking on SCAN ROTATION, in the **Scan** menu, places a large green circle in the active Quad with a small circle in the top right corner. At a point on the perimeter of the large green circle is a green triangle which denotes, by its position, the angle orientation of the sample relative to its original position when placed on the stage. To start with this will be at 12 o'clock. By keeping the left mouse button down on the green triangle it can be moved around the circle to choose a new orientation of the scan, the small circle follows suit.The computer software continuously updates the position orientation of the scan.This creates a different orientation on the viewing screen but retains the scanning direction on the specimen. The read-out positions displayed at the bottom of the Quad provide information on the 'ACTUAL ROTATION' (original position in degrees), the 'TARGET ROTATION' (the selected position in degrees) and the 'ROTATION CHANGE' (the difference in degrees of rotation).

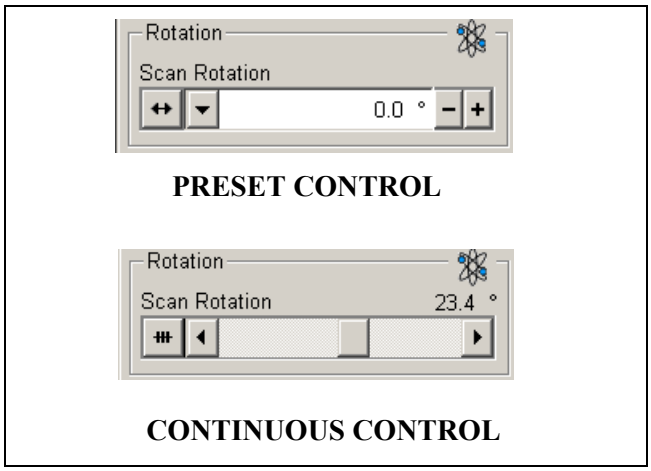
FIGURE 6-18 SCAN ROTATION



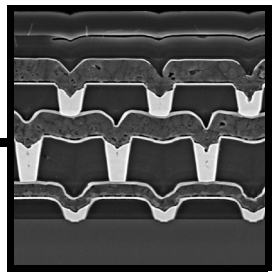
Clicking on or close to the numbered angles around the perimeter of the circle will cause the beam to drive to that angle and the green triangle will update on screen on both circles. The smaller circle in the top right of the Quad remains on-screen when Scan Rotation is switched off, if the angle is greater than 0 degrees, to inform the user of the orientation. The screen dialog can also be activated by selecting **Shift + F12** on the keyboard.

Scan Rotation can be operated from the **Beam** page using the preset/ continuous control adjuster in the module labelled ROTATION.

FIGURE 6-19 SCAN ROTATION FROM THE BEAM PAGE



7 MAINTENANCE



This section describes the maintenance necessary for the Nova NanoLab that can be carried out by the supervisor/user. For the Nova NanoLab User maintenance is at a minimum due to Gun and Column designs and the long up time expected from this class of instrumentation. Therefore the more complex maintenance is normally contained in a service contract to be performed by a qualified xT SEM/FIB service engineer.

At the user level items such as the following can be maintained:

- E-Column aperture maintenance
- Stage maintenance
- Dry Pump Check

!

CAUTION! Parts that operate in vacuum should be handled carefully using clean gloves. Parts not in use should be stored in suitable containers or packed in aluminium foil.

NOTE: Gas back fill (N_2) should be maintained while the specimen chamber is at ambient pressure. However, to avoid gas wastage it is recommended that the chamber should be left open no longer than necessary.

7.1 E-Column Aperture maintenance

E-Strip Aperture Module

This is a improved design of the original E-Column aperture using more axial stable materials with a Molybdenum finish. The strip has 5 aperture positions now with a 1 mm alignment hole in the frame and not the aperture. The strip comes pre aligned in a metal module which is connected to the end of the Aperture rod by a Titanium screw. The module is considered a consumable and therefore would be normally replaced when heavily contaminated. Only if a plasma cleaner is available these aperture modules can be cleaned while still connected to the rod. No other cleaning method should be used. There is a heater in the rod to assist as a cleaning mechanism for high water vapour or expected high contamination levels while operating in the column. All screws are of Titanium so not to have any magnetic effect.

FIGURE 7-1 ELECTRON COLUMN APERTURE MODULE

7.1.1 Removing the Aperture rod

With the high voltage off, let the specimen chamber up to atmospheric pressure. The E-Column Aperture rod is held at the same vacuum as the specimen chamber so no special vacuum need be broken to remove it.

If connected remove the heater cable from the outer end of the rod.

Unscrew the end of the Aperture rod and carefully remove it from the microscope. Preparation to clean or replace apertures should be immediately available as the specimen chamber has to stay at atmospheric pressure for the duration of maintenance.

7.1.2 Cleaning the Aperture Module

This is only possible if a Fischione Plasma cleaner is available. Take the complete rod with module attached and place in the TEM opening on the plasma cleaner. The screw at the end of the Aperture rod screws into the TEM opening and seals against the rod ‘o’ ring.

Give the rod 5 minutes at 4.5 volts plasma generation. This should remove all hydrocarbon base contamination. If the contamination is stubborn longer times will be necessary, this will not damage the aperture as the plasma only removes organic based material.

7.1.3 Replacing the Aperture Module

The new Aperture Module comes in a fluoroware container, has been pre-cleaned. and is ready to be fitted to the rod.

Firstly, release the Titanium screw holding the old module onto the rod. Keep the screw in the hole of the rod and let the module fall away.

Open the new module pack and let the new module sit with the connection end uppermost to the edge of the container base.

Now pick up the new module with the Titanium screw end and fasten, making sure of a good fit.

7.1.4 Replacing the Aperture rod

Check that there are no fibres on the rod ‘o’ ring. Do not grease the ‘o’ ring.

Replace the Aperture rod back into the Aperture Adjuster assembly on the column and turn the end screw mechanism until the holder is hand tight.

Pump the microscope specimen chamber

Reconnect the heater cable to the outer end of the rod if necessary.

Set the aperture at a 30 micron hole so that alignment can be performed.

7.1.5 Aperture availability

These apertures are at present used and come in two size types.

FP 6174/33 Mo Strip Aperture (30,30,40,50,100 micron) This type can be used for general applications including EDX.

FP 6174/53 Mo Strip Aperture (30,30,50,30,30 micron) This type can be used for high resolution applications such as low voltage.

7.2 Stage maintenance

Specimen Holders

Recommended cleaning procedures are given below for parts which operate in vacuum and that are subject to possible contamination. Frequency of cleaning is, in most cases, determined by necessity (image quality or astigmatism level).

7.2.1 Cleaning specimen holders

1. Clean these parts using cotton wool and a mild abrasive domestic cleaner (CIF) (see list of preferred cleaners at the end of this chapter).
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using a neutral pH cleaning fluid.
4. Rinse in distilled water for 5 minutes.
5. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a.
6. Rinse in alcohol p/a.
7. Dry thoroughly under an infra-red lamp (15 min. to 1 hr.) at a temperature of between 80°C and 100°C.

Stage mechanics

Checking the condition of the stage should be a weekly exercise as many differing samples may be exchanged in this time period. Some samples may be powders or composite materials that inadvertently drop particles on or in the stage. If a Silicon wafer breaks in the chamber it can shatter into hundreds of pieces. In this case the stage should be thoroughly cleaned before attempting movement again.

7.2.2 Cleaning Stage parts

NOTE: Abrasives and solvents must not be used on the stage moving parts.

Cleaning should be made by using dry nitrogen gas bursts around the stage mechanics to blow out any foreign materials. Make sure the final lens and detectors are protected from the turbulence. Do not use sharp metal objects to scrape away debris. A fine pair of plastic tweezers can be used to pick up difficult particles. Spillages on the stage should be wiped up using a lint-free cloth, followed by blowing with N_2.

7.3 Scroll Pump Check

7.3.1 Periodic check

This should be planned every 3 months, although every month is more realistic if sample loading is at a high frequency.

It is very important that the pipes to and from the pump are not restricted in any way. If the pump exhaust pipe is fitted to an internal company system it is important that the gas flow is unrestricted by the system capability, otherwise back pressure can occur which will overheat the dry pump.

7.4 List of Applied Cleaners

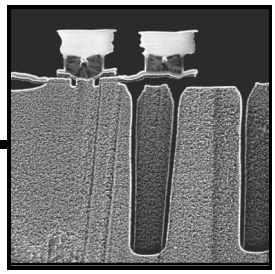
- De-ionised or distilled water
- Ethanol - C_2H_5OH
- Ethanol p/a (Pro Analysis: 99.8% pure) - C_2H_5OH
- Neutral pH cleaning fluid (soap solution)
- CIF* or SOFT SCRUB (household fine abrasive cleaner)

*** CIF is found in the following countries**

Country	Name
Austria	*
Australia	*
Finland	*
France	*
Germany	*
Italy	*
Japan	*
Netherlands	*
Switzerland	*
UK	*
USA	SOFT SCRUB

WARNING! AS CLEANING SOLVENT ETHANOL IS HIGHLY FLAMMABLE, DO NOT USE OPEN FLAMES AND DO NOT SMOKE WHILE CLEANING. VENTILATE THE ROOM PROPERLY.

8 HARD & SOFTWARE OPTIONS



This chapter covers hardware and software that is an option either integrated in, or accessory to the Nova delivered.

The items covered here are:

- Auto FIB (FP3550/00)
- Auto Slice and View (FP3550/20)
- Auto TEM (FP3550/10)
- Selective Etch XT Software
- Vise sample holder

Other options will be added to this chapter when they become available in future releases.

For further information on any of these items please contact your local FEI representative.

AutoFIB Software

Use AutoFIB™ to run xT systems without supervision. It is a general purpose automation program for samples with milling locations that are not in a regular array. Applications include TEM sample preparation and cross-sectioning. After defining the milling patterns, associated data, and operation in an AutoFIB script, start the script using AutoFIB.

Use AutoFIB in two ways:

- Set up a multiple-location task by entering stage coordinates, beam settings, and patterns for each position in the AutoFIB script. For example, to mill four cross sections on a chip, define the four tasks in the script, start AutoFIB in AutoRun mode, then let AutoFIB complete the work.
- Run identical tasks at several locations. Write an AutoFIB script for a single cross section without stage coordinates, thus allowing the script to be used at any location. Using a system with a sample holder that allows for repeatable placement, run the AutoFIB script to mill in a partially automated step-and-repeat fashion.

The following information can be specified in the AutoFIB script:

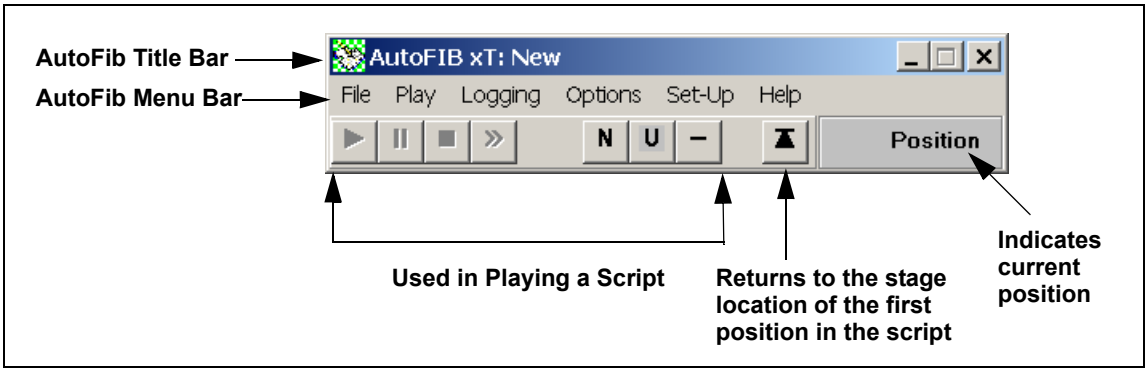
- Stage X, Y, R, T, and Z positions
- Aperture setting
- Focus voltage
- Stigmation values
- Beam shift
- Scan rotation, speed, and resolution
- Contrast/brightness
- Pattern information, including magnification, mode, pattern type, size, and location (*.ptf* files can be saved and read)
- Auto Locate and Drift Control
- Name of an AutoScript script

Installing AutoFIB

1. Close all applications.
2. Insert the AutoFIB installation CD.
3. The install wizard starts. Click Next, Install and Finish to install. The install program installs the AutoFIB program and a desktop icon for AutoFIB.

4. After the xT software is running, click the AutoFIB icon on the desktop to start the program or select START > Programs > FEI Company > Applications > AutoFIB. The AutoFIB window opens.

FIGURE 8-1 AUTOFIB WINDOW



AutoFIB Title Bar

The title bar of the AutoFIB window indicates the active AutoFIB mode.

TABLE 8-1 AUTOFIB MODES

Mode	Description
New	AutoFIB starts in New mode.
Edit	Entering or making changes to a script puts AutoFIB into Edit mode. Stopping a running script returns AutoFIB to Edit mode.
AutoRun	Running a script puts AutoFIB into AutoRun mode. The toolbar is outlined in red.
Pause	Pausing a running script puts AutoFIB into Pause mode.

AutoFIB Menus

AutoFIB has five menus: File, Play, Logging, Options, and Set-Up.

File Menu

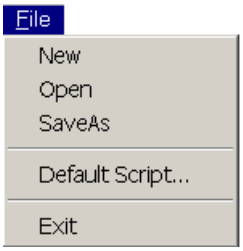


TABLE 8-2 FILE MENU OVERVIEW

Menu Item	Description
New	Specifies a new AutoFIB file.
Open	Opens an existing AutoFIB file.
SaveAs	Saves the AutoFIB file with a new name. The file name extension is *.sct*.
Default Script	(Not used in current version.)
Exit	Exits AutoFIB.

Play Menu

The Play menu controls editing of AutoFIB scripts and AutoFIB milling activity. Most of these functions are also accessible from the AutoFIB toolbar.

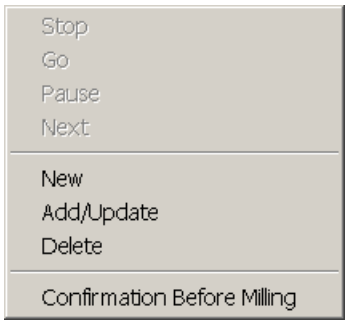
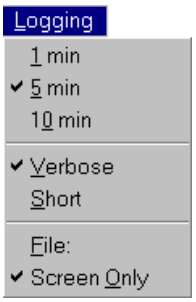


TABLE 8-3 PLAY MENU OVERVIEW

Toolbar Button	Menu Item	Description
■	**Stop**	Stops the automatic run of the script. The button is gray when the script is not running.
▶	**Go**	Runs the specified AutoFIB script.
⏸	**Pause**	Pauses the running script.
»	**Next**	Steps between each position (block of data). AutoFIB must be in either Edit or Pause mode.
N	**New**	Adds a new position (and block of data) to the script.

TABLE 8-3 PLAY MENU OVERVIEW

Toolbar Button	Menu Item	Description
U	**Add/Update**	Edits or updates the current block of data to reflect the currently selected parameters and preferences in the Scripting dialog box and the corresponding xT system values.
–	**Delete**	Deletes the current position (and block of data) from the script.
	Confirmation Before Milling	Stops the automated run at each new position and issues a prompt to confirm continuation of milling.



Logging Menu

The Logging menu has selections for logging AutoFIB activity and data.

TABLE 8-4 LOGGING MENU OVERVIEW

Menu Item	Description
1 min **5 min** **10 min**	Chooses a 1-, 5-, or 10-minute interval (logging frequency) for adding milling updates to the log files.
Verbose	Logs AutoFIB activity and data.
Short	Logs AutoFIB activity, for example, emission current adjustments and error messages.
File	Specifies a specific log file name. See File and Screen Only.
Screen Only	Displays the logged data onscreen; does not save data in a log file.

File and Screen Only

During operation, the AutoFIB activity displays onscreen. Optionally, also save the information to a log file.

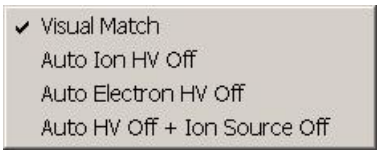
The log files contain information about the progress of the script and can be used for troubleshooting or record keeping. The file contains the date and time of AutoScript activity, with new information logged after the existing data.

The screen log is limited to 30 kB. After it reaches this size, earlier log entries are progressively deleted as more data is added (first in, first out).

To save data in a file, select Logging > File. A dialog box similar to the Save As dialog box displays. The file name becomes part of the menu item, such as File: *omn63.log*.

Data from different sessions can be appended to the same file; the previously stored information is not overwritten. Log files are text files that may be viewed with Microsoft® Notepad or a word processing program. Note that some editors, such as Notepad, can handle only certain file sizes. If the file is too large, use a word processor to open it. If you query the log file while AutoFIB is in AutoRun mode, an error may occur if AutoFIB attempts to add data to the file.

Options Menu



The Options menu determines how the microscope behaves during and after running an auto FIB session.

TABLE 8-5 OPTIONS MENU OVERVIEW

Menu Item	Description
Visual Match	An image dialog box is displayed whenever an image recognition routine (match command) is performed in an AutoScript script. Selected is the default setting.
Auto Ion HV Off	The system turns off the HV of the ion beam at the end of the AutoRun mode operation or if an error occurs. An error occurs e.g. if the stage does not reach the requested location. The default setting is not selected.
Auto Electron HV Off	The system turns off the HV of the electron beam at the end of the AutoRun mode operation or if an error occurs. An error occurs e.g. if the stage does not reach the requested location. The default setting is not selected.
Auto HV Off + Ion Source Off	The system turns off the HV of both beams and the source of the ion beam at the end of the AutoRun mode operation or if an error occurs. An error occurs e.g. if the stage does not reach the requested location. The default setting is not selected.

Set-Up Menu

TABLE 8-6 SET-UP MENU OVERVIEW

Menu Item	Description
Scripting	Opens the Scripting dialog box from which you define the AutoFIB milling scripts.
Drift Control	Opens the Drift Control Defaults dialog box from which you set the parameters for Auto Locate.

Drift Control

Drift Control compensates for image drift. It can be selected as a preference during scripting setup. Drift Control is also available as a standalone program (see “Dynamic Drift Control”).

This menu item accesses the Drift Control Defaults dialog box, where you can specify default information for scripts.

Default Information

Specify Auto locate information in the Drift Control Defaults dialog box, which is opened from Set-Up > Drift Control or from the standalone Drift Control program.

FIGURE 8-2 DRIFT CONTROL DEFAULTS

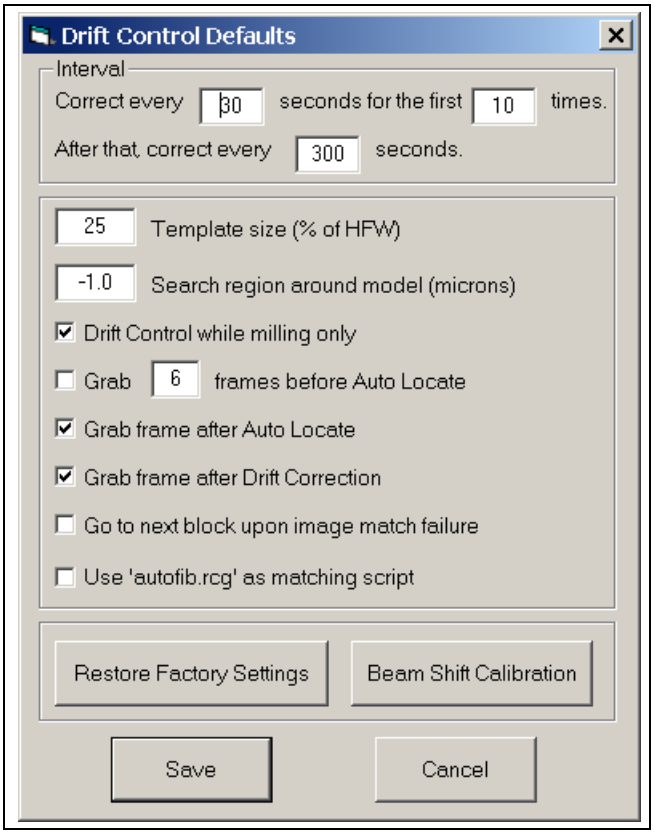


TABLE 8-7 DRIFT CONTROL DEFAULTS DIALOG BOX

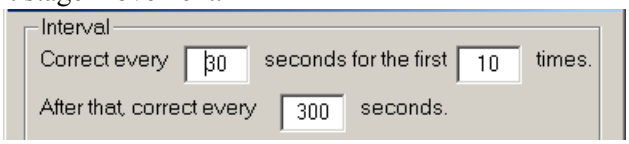
Interface Item	Description
Interval group	Specifies the time interval between drift corrections in the Interval group. Use more frequent drift correction at first to compensate for recent stage movement.  Each time the specified duration has elapsed, patterning pauses while the system checks for drift and makes needed corrections. Patterning then continues until the next drift correction time occurs.
Template size text box	Defines the size of the template in relation to the full screen. For example, a size of 25% defines a template with ¼ the width of the system's screen (HFW = Horizontal Field).
Search region around model text box	Relocates the locating feature after image drift caused by milling. Enter a positive to limit the search area to a feature near the template. Enter -1.0 (default value) to search the entire field of view.
Drift Control while milling only	Makes drift corrections during milling. This selection is available only when using the standalone Drift Control program.
Grab X frames before Auto Locate	Selects the number of frames to be grabbed. On some samples, the image contrast changes markedly after one or two frames are acquired, particularly if the area had not been imaged for some time. This is because grabbing an image helps clean up contaminants that may distort the image.
Grab frame after Auto Locate	Updates the image field before milling continues. When the system locates a feature during Auto Locate, the beam moves over the correct location while the image field continues to display the pre-corrected image. This discrepancy can be confusing.
Grab frame after Drift Correction	Updates the image field before milling continues. When the system finishes drift correction, the beam moves over the correct location while the image field continues to display the pre-corrected image. This discrepancy can be confusing.
Go to next block upon image match failure	Directs the script to continue running even if a match failure is detected. With this feature, the system may run unmonitored, as a failed image match does not stop the script. This could cause the sample to be only partially processed at a failed location.

TABLE 8-7 DRIFT CONTROL DEFAULTS DIALOG BOX

Interface Item	Description
Use 'autofib.rcg' as matching script	AutoFIB uses a standard, default matching routine during Drift Control and Auto Locate. If the system has difficulty matching samples, select this option. AutoFIB then uses the script *autofib.rcg*, which you can customize. Selecting this option offers flexibility for cases in which the simple autocontrast adjustment in the default routine is not sufficient to produce reliable matches. The script *autofib.rcg* calls the automatically generated script *match.rcg* at each recognition location. If you know specifically the feature you expect to find, you can modify *autofib.rcg* to use a particular bitmap for recognition. The script *match.rcg* uses the match template set up during the script definition.
Restore Factory Settings button	Resets the template size, interval, expected drift, etc., to the original Drift Control default settings. Calibrate beam shift after restoring the default settings.
Beam Shift Calibration button	Determines beam shift sensitivity. This establishes the voltage required to move a locating feature back to a desired location and helps in successfully locating those features.

Using Templates

When you define a script that uses Auto locate, the system prompts for a locating feature. It can be any distinguishable feature near the milling area. A movable template marks the feature on the screen image.

NOTE: Never place a template over a milling area. When milling changes the feature, Auto locate will be unsuccessful.

The locating feature does not need to be within the initial image area displayed on the screen, but the beam shift limit is 100 µm away from the milled area. The beam shift offset used to locate the feature is stored in the script. Position the feature in the field of view using beam shift, and reposition the template if necessary. Do not change magnification or move the stage. During Auto Locate, the beam shift offset is automatically applied before the alignment image is acquired.

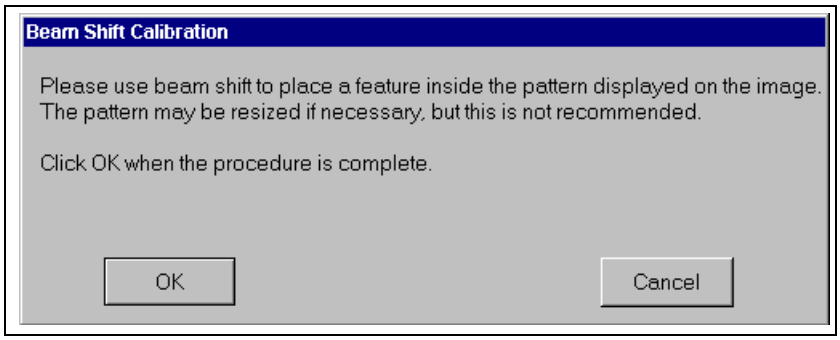
Calibrating Beam Shift

When calibrating beam shift for the first time after installation or after restoring factory settings, perform the action twice. The first calibration involves only a small beam shift; the second calibration uses a larger shift based on the measured values. Thereafter, beam shift calibration is required infrequently.

NOTE: Make sure the image HFW is 100 µm or less; otherwise, the beam shift may go out of range when performing the calibration.

The calibration process is similar to that used for locating a feature when Auto locate is selected as a preference for the scripts. A template is placed in the lower left of the screen for positioning over a locating feature. The system grabs a frame, electronically shifts the beam in X, grabs another frame, calibrates the beam shift by determining the distance of movement in pixels, then converts the distance into µm. The process is repeated for Y.

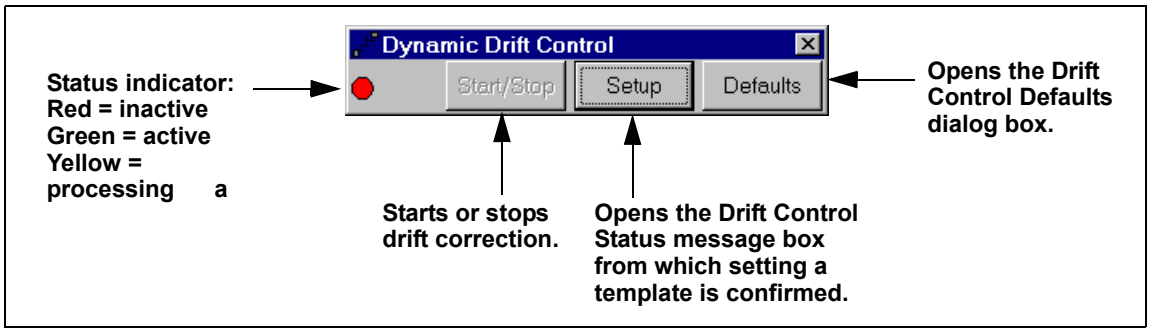
FIGURE 8-3 BEAM SHIFT CALIBRATION


Beam Shift Calibration
Please use beam shift to place a feature inside the pattern displayed on the image.
The pattern may be resized if necessary, but this is not recommended.
Click OK when the procedure is complete.
OK
Cancel

Dynamic Drift Control

Access standalone Drift Control by double-clicking the Drift Correction icon on the desktop or by selecting START > Programs > FEI Company> Applications > DriftCorrection. The Dynamic Drift Control menu bar displays. Use this menu bar to run Drift Control from outside AutoFIB.

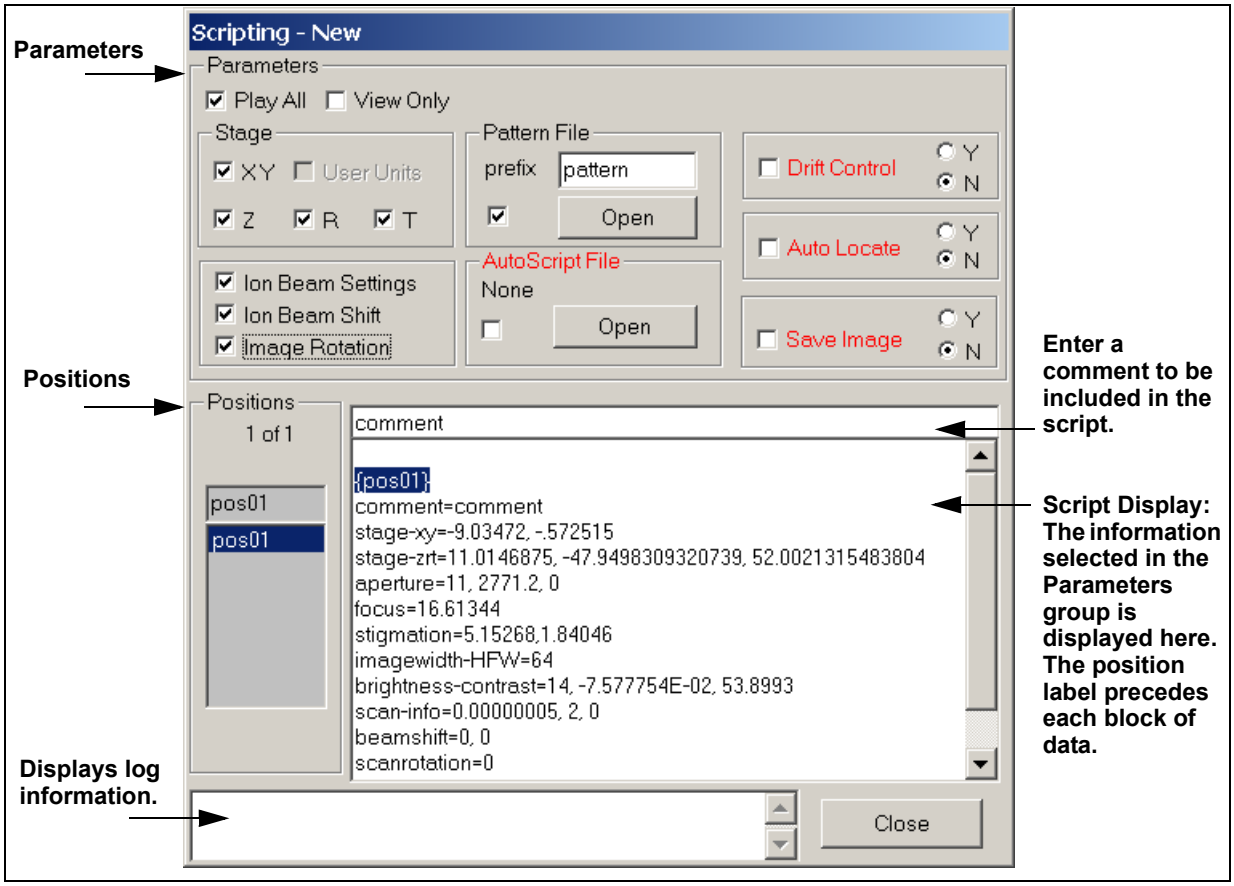
FIGURE 8-4 DYNAMIC DRIFT CONTROL MENU BAR


Dynamic Drift Control
Start/Stop
Setup
Defaults
Status indicator:
Red = inactive
Green = active
Yellow = processing a
Starts or stops drift correction.
Opens the Drift Control Status message box from which setting a template is confirmed.
Opens the Drift Control Defaults dialog box.

Scripts

A script is a set of directions that can be executed without user interaction. AutoFIB scripts are stored as text files. A single script may have multiple milling operations. The scripting information is entered in the Scripting dialog box accessed from Set-Up > Scripting.

FIGURE 8-5 SCRIPTING DIALOG BOX



Parameters

Scripts contain two types of information: preferences and xT system values (parameters). These can be different for each position in the script.

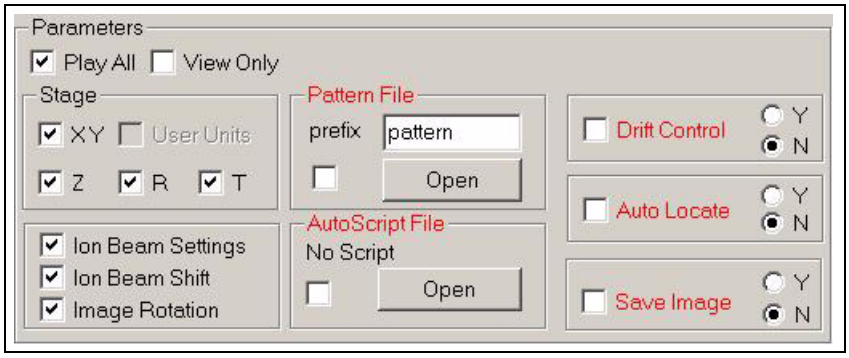
Select the check boxes next to the preferences and parameters to be included in the script. Update the script by clicking NEW to add a new position, or ADD/UPDATE to modify the selected position. The appropriate, current, xT system values are added to the script.

In the Parameters group, the selected preferences and parameters are displayed in black. The preferences and parameters not in the current block of data are displayed in red to help you see which settings you may have overlooked.

Parameters that have Y (yes) and N (no) option buttons next to them can be set for each position in the script. For example, select Auto locate as part of the script by selecting its check box. Then turn it on for a position by selecting the Y option button or turn it off for other positions by selecting the N option button.

NOTE: If you select the Y option button but fail to select the check box, the parameter is not entered into the script.

FIGURE 8-6 SCRIPTING PARAMETERS



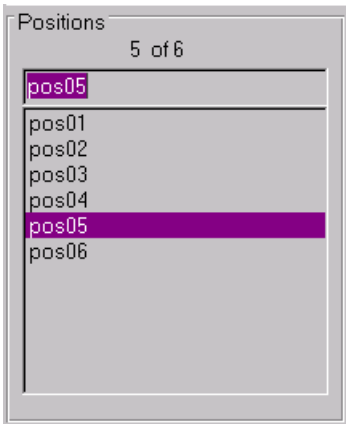
The following table describes the preferences and parameters in the Scripting dialog box. The script commands become part of the block of data for the position.

TABLE 8-8 SCRIPTING PARAMETER SETTINGS

Check Box	Description	Script Commands
Play All	When selected, all data in the script is sent to the system, regardless of the check boxes for each individual item. This is the normal operational mode for AutoRun. When Play All is not selected, only the data for the selected parameters is sent to the system. All other data in the script is ignored.	(not applicable)
View Only	Use this mode to review the parameters saved for each position. The script steps through the stage positions without actually moving the stage or updating the xT system values. Also, moving to a different script position using NEXT or by double-clicking in the Positions list box does not send any commands or data to the system.	(not applicable)
Stage:		
XY, Z, R, T	Includes X, Y, Z stage coordinates, rotation, and tilt in the script. The coordinates display in µm; rotation and tilt in degrees.	stage-xy stage-zrt
User Units	Defines X, Y stage coordinates in user units.	user-units
Ion Beam Settings	Includes aperture, focus, stigmation, rotation, brightness/ contrast, and scan information in the script. The settings are expressed in the xT interface.	aperture focus stigmation brightness-contrast scan-info
Ion Beam Shift	Includes beam shift information in the script.	beamshift

TABLE 8-8 SCRIPTING PARAMETER SETTINGS

Check Box	Description	Script Commands
Image Rotation	Includes scan rotation information for the ion beam in the script.	scanrotation
Pattern File	Includes pattern settings in the script via standard pattern files (.ptf files). Patterns are saved to a pattern file with name “prefix<position number>.ptf” when New or Update is clicked. The pattern file is read when the script is executed. With the Open button, an existing pattern file can be opened, its contents is copied to “prefix<position number>.ptf”.	pattern-group
AutoScript File	Specifies an additional Autoscript script that will run after the AutoFIB script for each position.	sub-script
Drift Control with Y, N options	When this option is set to YES, the software determines at regular intervals if the sample has drifted. If it has, the location of the beam is adjusted back to correct the coordinates. Drift Control defaults are entered in the Drift Control Defaults dialog box accessed from the Set-Up menu.	drift-control-data drift-control
Auto Locate with Y, N options	When this option is set to YES, the software determines (after moving the stage but before milling) the XY offset from the selected feature and makes a beam shift to compensate. This is a one-time-only drift correction to compensate for stage moves.	auto-alignment
Save Image with Y, N options	When this option is set to YES, the image is scanned at current beam settings and saved as a *.bmp* to the default directory when milling is complete.	save-image



Positions

The active position of the script is highlighted on the list. Each position has a block of data in the script and, therefore, can use different settings.

The default label for the first position is “pos01.” You may change it by entering a new label. The next position label is based on the previous label. For example, if the previous label is “area05,” the next label will be “area06.” The labels are sorted alphanumerically in the Positions list box and are used in that order during AutoRun mode. The maximum length of a label is 8 characters; image files are saved using the position labels, with the extension *.bmp*.

Creating and Running a Script

Creating a Script

1 Start xT.

2 Start AutoFIB from the desktop or Start menu. The AutoFIB menu bar displays and continues to display on top of any other open program.

3 Select Set-Up > Scripting. The Scripting dialog box displays.

4 Select the preferences and parameters for the script.

5 Click N to add the new data to the script. You may change the label for the position.

6 If Auto Locate was selected, you are prompted to define an area for a locating feature.

7 Repeat steps 4–5 for each milling position.

8 After entering milling positions, click the "top" toolbar button on the AutoFIB menu bar; the stage moves to the first position. The system is now ready to run the script.

Previewing a Script

Preview the milling script before using AutoRun mode by selecting STAGE XY and VIEW ONLY in the Scripting dialog box. Click NEXT in the AutoFIB toolbar to step through the stage positions without actually moving the stage or updating the coordinates. Make any changes to the script using Edit mode.

AutoRun Mode

During AutoRun mode, xT system values display onscreen and can be saved periodically to log files for later review.

NOTE: Do not minimize the xT interface when the AutoRun mode is operating.

Before milling begins, make sure the hard drive has enough space for the image and log files that will be created.

To set up the operation:

1. From the Options menu, set the Detector to either low or normal gain. Normal Detector Gain is standard.
2. Choose whether or not to turn the beam off if an error condition occurs during AutoRun mode. Usually, Auto Beam Off is not selected.
3. Choose the logging interval from the Logging menu. The standard settings are 5 minutes, Verbose, and Screen Only.
4. Run the AutoFIB script. Verify that PLAY ALL is selected in the Scripting dialog box; otherwise, only selected data is sent to the system.

Click GO (PLAY CURRENT SCRIPT) in the AutoFIB window. A dialog box prompts "Set parameters for current location?"

1. Select YES to set the system with the values for the currently selected position first, and then begin milling.
2. Select NO to begin milling with the pattern and beam current already in use.
3. Select CANCEL to abort the automated milling process.

AutoFIB checks the xT system every 3 seconds to see if milling has stopped. When milling is complete, an image is grabbed and stored if SAVE IMAGE was selected. The stage then moves to the next location and the beam parameters are updated. Milling starts at the next location.

1. To suspend operations (including logging) at the current location, click PAUSE. A dialog box prompts "Allow current milling to finish?"
2. Select YES to allow the current patterns to complete milling. Once milling is finished, the script will not proceed to the next position.

   Select NO to stop milling temporarily.

Click GO to resume AutoRun mode.

1. To interrupt milling at the current location, stop patterning in the xT interface by clicking on the Stop Icon in the Tool bar. AutoFIB moves to the next location and continues.

2. To stop the script, click STOP. This does not interrupt the current pattern milling. A dialog box prompts "Allow current milling to finish?"

   Select YES to allow the current patterns to complete milling. Once milling is finished, the stage will not move to the next location.

   Select NO to stop milling even if the pattern is not finished milling.

3. When the operation is complete, review the log file and images, if selected.

Messages

Examples of some of the messages described in this section are shown with values that will be different on your system.

Log Messages

The following table describes the AutoFIB activity messages. All messages start with date and time values.

TABLE 8-9 LOG MESSAGES

This Log Message . . .	Occurs When . . .
Start	GO is clicked. This is always the first log message.
Pause	PAUSE is clicked. This can be done by the user or by AutoFIB if an error has occurred.
Stop	STOP is clicked.
Set up: 2 of 20 - pos02 Emis: 2.2µA	Milling parameters are set. The number and label of the current position are given with the emission current.
Move over xy=12.3, 14506.4	The stage is moved in x and y. The new location is displayed and compared with the target values. If the stage is more than 1 µm from the target location, the move is redone. If the stage does not reach the required range after three attempts, the milling process is stopped.
ReDo stage move	A stage move is attempted again. See “Move over xy” above for more information.
Milling over	Milling of the current pattern(s) has finished (either timed out or stopped by the user in xT).
Save Image: c:\xT\autofib1\pos02.bmp	An image is saved in the specified file. The system assumes there is sufficient disk space to save the file.
Finish	The AutoFIB script has completed without interruption.

Error Messages

The following table describes errors that may occur while working with the AutoFIB software.

Milling continuing STOP or PAUSE is clicked and the choice is made to allow the pattern to finish.

Milling stopped STOP or PAUSE is clicked and the choice is made to stop the milling. This message also appears after milling halts due to an error.

TABLE 8-10 ERROR MESSAGES

This Error . . .	Means . . .
Unable to initiate xT AutoLIB.	There is a problem with the link to the xT program. These messages occur when the AutoFIB program cannot make contact with xT or the associated xT Services. You must start xT, or restart xT Services and xT software, before running AutoFIB.
Press Cancel to run in test mode.	
Messages headed: "OLE Connection: Error"	
Could not find server.	
Could not find xT.	
Stage did not reach requested position.	After three attempts the stage did not reach the requested position. Ensure that the X,Y values are valid and the stage is working correctly.
Automated processing halted: File Handling Error	AutoFIB cannot write the log file to the disk drive. Verify that the file name is valid and there is space on the drive.
Milling not started.	The emission current is out of range when the AutoFIB enters AutoRun mode.
Error during Auto Locate.	Check *dc.log* or current file that contains log data related to Auto Locate routines to determine the problem.
Patterning Error: pitch too small, Increase beam current, magnification, blur or Decrease overlap.	Error when AutoFIB tries to start patterning. The patterning pitch is too small. Check if the pattern can be milled by clicking START PATTERNING on the xT toolbar.

Additional Notes

Cleaning Cross Sections

In AutoRun mode, each pattern is erased before the next one is loaded. Cleaning cross-section patterns should be used only in serial pattern order. If a cleaning cross-section pattern is present when you select the regular cross-section pattern, an error message may appear during pattern setup because the pattern order is automatically changed to parallel. This error does not occur in AutoRun mode.

NOTE: Pattern order is selected on the Patterning Page of the xT user interface.

Log File Examples

Below are two example log files (Verbose mode) created during the running of AutoFIB scripts.

Patterns in AutoFIB Script

This example script was started at 15:24. Mills occurred at three locations before AutoFIB stopped at 15:30. (An AutoFIB operation could run for hours.)

```
10-28-04 14:57:05 Start
10-28-04 14:59:05 Set up: Mill: 1 of 3 - pos01
10-28-04 14:59:05 comment=comment
10-28-04 14:59:05 aperture=15, 20740, 0
10-28-04 14:59:05 focus=16.5
10-28-04 14:59:05 stigmation=0,0
10-28-04 14:59:05 imagewidth-HFW=250
10-28-04 14:59:05 brightness-contrast=14, 0, 4.949132E-06
10-28-04 14:59:05 scan-info=0.0000003, 1, 0
10-28-04 14:59:05 scanrotation=0
10-28-04 14:59:05 beamshift=8.5, 3.666667
10-28-04 14:59:05 stage-zrt=15.8173415478988, -2.99386577638453E-04,
10.0042352674755
10-28-04 14:59:05 stage-xy= 6.0099185155797,  4.37424848170415
10-28-04 14:59:08 pattern-group=pattern01.ptf
10-28-04 14:59:22 Milling over.
10-28-04 14:59:05 Set up: Mill: 2 of 3 - pos02
…
10-28-04 14:59:05 Milling over.
10-28-04 14:59:22 Set up: Mill: 3 of 3 - pos03
…
10-28-04 14:59:40 Milling over.
10-28-04 14:59:40 Finish
```

Using a Subscript

This script calls a subscript for each of the eight milling locations.

```
08-30-00 14:15:22 Start
08-30-00 14:15:22 Set up: Mill: 1 of 8 - pos01
08-30-00 14:15:22 beamshift=0.000, 0.000
08-30-00 14:15:22 scanrotation=0.000
08-30-00 14:15:22 stage-zrt=2212.727, , -0.002
08-30-00 14:15:23 stage-xy=-18.164, 1678.354
08-30-00 14:15:42 Milling over
08-30-00 14:15:42 Run SubScript: C:\xT\AutoFIB\tem wizard\data1.ini
Start matchcrosses.rcg
leftxy 1.00000000, -16.60916858, -0.95698540, 0.49500000
rightxy 1.00000000, 14.51078599, -0.95962849, 0.48600000
midpointxy, -1.04919130, -0.95830695, 31.11995457
Matchcrosses successful
Beamchecked, expected: 300.00000000 actual: 448.00000000 loops:
59.00000000
Step 0 successful
.
.
.
End SubScript: Result = 1
08-30-00 14:46:14 Set up: Mill: 2 of 8 - pos02
08-30-00 14:46:14 beamshift=0.000, 0.000
08-30-00 14:46:14 scanrotation=0.000
08-30-00 14:46:14 stage-zrt=2212.727, , -0.002
08-30-00 14:46:15 stage-xy=-18.148, 1602.638
08-30-00 14:46:28 Milling over
08-30-00 14:46:28 Run SubScript: C:\xT\AutoFIB\tem wizard\data2.ini
.
.
.
08-30-00 17:57:21 Set up: Mill: 8 of 8 - pos08
08-30-00 17:57:21 beamshift=0.000, 0.000
08-30-00 17:57:22 scanrotation=0.000
08-30-00 17:57:22 stage-zrt=2212.727, , -0.002
08-30-00 17:57:23 stage-xy=-358.844, 1571.284
08-30-00 17:57:35 Milling over
08-30-00 17:57:35 Run SubScript: C:\xT\AutoFIB\tem wizard\data8.ini
```

```
End SubScript: Result = 1
08-30-00 18:27:24 Finish
08-30-00 18:27:25 Ion Column and HV Switched Off
```

Auto Slice & View Software

Auto Slice & View (Auto S&V) automatically mills consecutive slices through a three-dimensional feature, collecting images of the slices. When the operation is complete, you can review the images individually or in an animated sequence called a “movie.” You can also review images offline, using any bitmap editor. For most jobs, once you set up the system, you can leave it unattended.

Contents of This Document

This document describes

- Use of Auto S&V
- Optional automated versus manual steps
- Viewing Auto S&V images in an animated sequence
- Troubleshooting procedures

How Auto S&V Works

You can obtain information about a feature by examining its entire three-dimensional profile. Auto Slice & View minimizes the time required to collect this information for any application where a feature is cut and imaged.

In Auto S&V, you supply the following parameters for the overall area to be sliced:

- Milling and deposition parameters
- Number and size of slices (or more accurately, small boxes) to be milled
- Scan parameters for electron beam imaging

The application then provides this information and other task-specific information to xT, which uses it for milling and image acquisition. Although Auto S&V checks for input errors, inappropriate parameters can lead to undesirable results or error messages from xT.

Process Steps

An Auto Slice & View operation consists of up to three process steps; protective coating, rough cut, and slice. These steps are optional and can be performed in any combination, but all selected steps are performed in the following order:

- In the protective coating step, the system deposits a protective coating over the intended slice area. This coating is used to protect surface features or to ensure that a potentially mobile feature remains fixed.

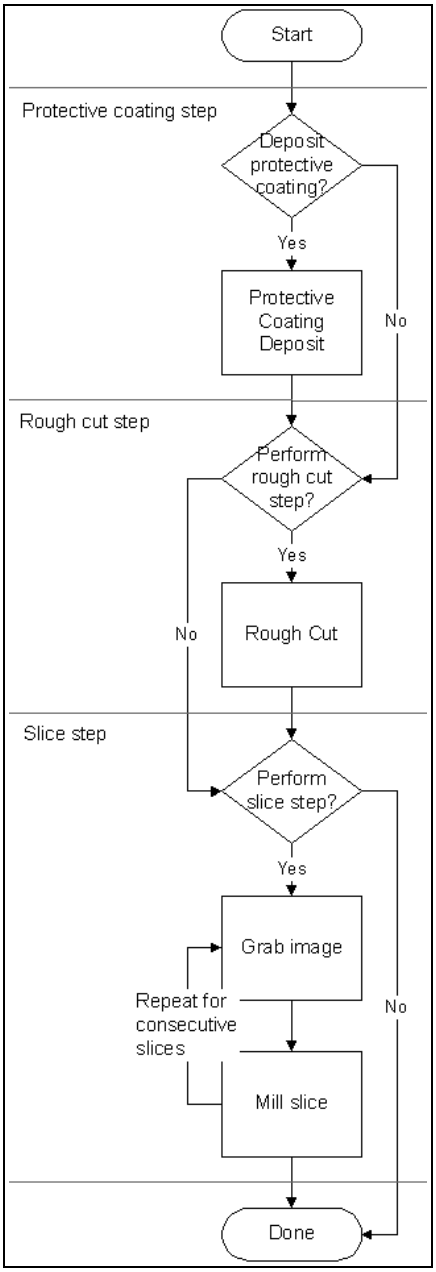
  In this step, Auto S&V prompts you to insert the appropriate GIS needle, align for image shift, retract the GIS needle, and realign for image shift. Because this step requires user interaction, users often choose to perform it directly in xT.

- In the rough cut step, the system mills a standard xT cross section to allow electron beam imaging of the face of the feature of interest. While many users perform this step directly in xT, it can also be done using Auto S&V.

- In the slice step, the system creates and saves an electron beam image of the face of the mill, then removes material with the ion beam, repeating these operations until the specified number of slices has been made. This step requires no interaction after initial setup, and many users utilize Auto S&V to perform only this step.

The following flowchart provides an overview of this process. Auto S&V can also be used to view images of the mill process, but this step is not included in the flowchart since it can be performed independently at any time.

FIGURE 8-7 AUTO SLICE & VIEW PROCESS STEPS



Application Selection

To include a particular process step in the Auto S&V operation, select an Application file (Material file) for that step. To exclude a particular process step, set the application to NONE.

To include the protective coating step, select an application in the Coating option group, for example, use *Pt* for Platinum.

To include the rough cut and slice steps, select *Si* as the application in the appropriate option group.

Launching Auto S&V

Before launching Auto S &V, you must first start xT, if it is not already running.

To launch Auto Slice & View, click START > Programs > FEI Company > Applications > AutoSliceAndView.

User Interface

The Auto S&V user interface contains five dropdown menus and three main option tabs.

Menu Commands

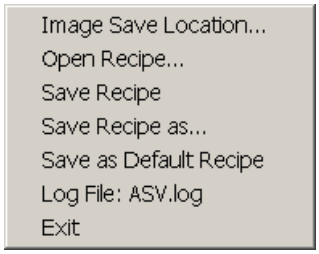


TABLE 8-11 FILE MENU COMMANDS

Menu Command	Description
Image Save Location	Accesses a dialog box used to specify the directory where images produced by Auto S&V will be stored.
Open Recipe	Loads the specified recipe and displays its parameters in the user interface.
Save Recipe	Saves the open Auto S&V recipe.
Save Recipe as	Saves the current parameters into an Auto S&V recipe, using the specified name and location.
Save as Default Recipe	Saves the current parameters as the default recipe. These values are loaded automatically whenever you launch Auto S&V. These parameters are stored in *default.asv*. Factory default values are hard-coded in the application and can be restored by deleting the existing *default.asv* and relaunching the application.
Log File	The name of the log file (without path).
Exit	Exits Auto S&V.

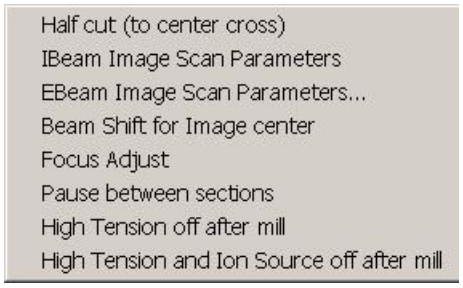

Half cut (to center cross)
IBeam Image Scan Parameters
EBeam Image Scan Parameters...
Beam Shift for Image center
Focus Adjust
Pause between sections
High Tension off after mill
High Tension and Ion Source off after mill

TABLE 8-12 SETUP MENU COMMANDS (Sheet 1 of 2)

Menu Command	Description
Half cut (to center cross)	Instructs Auto S&V to mill slices only to the halfway point, which is the center cross in the xT interface.
Ibeam Image Scan Parameters	Opens a dialog box used to set the resolution and scan time of the ion beam frame grabs in the Image section.

TABLE 8-12 SETUP MENU COMMANDS (Sheet 2 of 2)

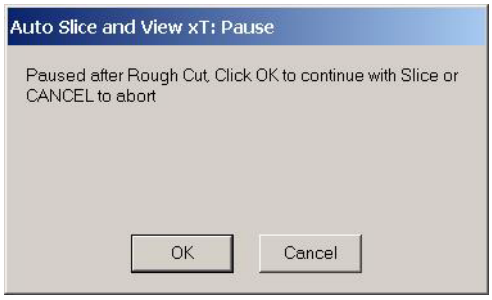
Menu Command	Description
Ebeam Image Scan Parameters	Opens a dialog box used to set the resolution and scan time of the Electron beam frame grabs in the image section.
Beam Shift for Image center	Sets the electron beam shift such that the face of the cross section remains centered in the field of view. Due to constraints in electron beam shift, this option is only available for overall slice heights up to 13 µm.
Focus Adjust	Instructs Auto S&V to apply focus correction for each new slice.
Pause between sections	Displays a dialog box (illustrated below) to allow manual intervention between each step in the Auto S&V operation (protective coating, rough cut, and slice).  Click OK to resume processing with the following step. Click CANCEL to abort the operation without completing the subsequent options.
High tension off after mill	Automatically turns off the electron & ion beam high tension/voltage when the Auto S&V operation is complete. Sources for both beams remain on.
High tension and Ion Source off after mill	Automatically turns off the electron & ion beam high tension/voltage and the ion beam source when the Auto S&V operation is complete.

TABLE 8-13 UTILITIES MENU COMMAND

Menu Command	Description
Clear All Patterns	Deletes all patterns from the current xT quadrant, including those not generated by Auto S&V.
Suggest Currents	Suggests ion beam currents based on the area of the individual patterns and the Auto S&V process step. No depth information is used. Therefore, the resulting mill times may be excessive.
Disable Aperture Change	Uses the beam current selected in xT, disabling the automatic ion beam aperture changes specified in Auto S&V. This option prevents pattern shifts that sometimes occur with aperture change. Select this option only if you plan to use the same aperture for every step of the Auto S&V operation. If you will not use the same aperture for every step, select the Pause between Sections option and manually change the ion beam current in xT.

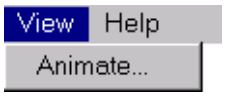


TABLE 8-14 VIEW MENU COMMAND

Menu Command	Description
Animate	Shows a “movie” of images collected during the slice routine.

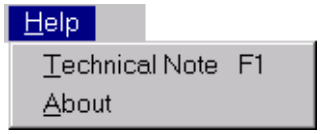
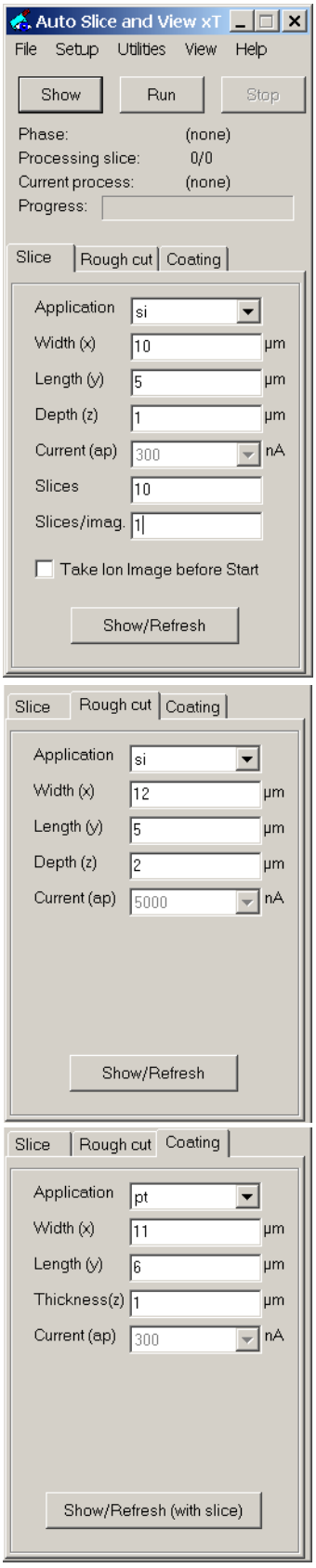


TABLE 8-15 HELP MENU COMMANDS

Menu Command	Description
Technical Note	Accesses this technical note in Adobe Acrobat® PDF format.
About	Displays the About dialog box, which contains the date and version of the Auto S&V code.



Option Groups

Option groups each correspond to an optional step in the Auto S&V operation.

- Options in the Slice group control the milling of successive slices.
- Options in the Rough Cut (pre-slice) group control the initial milling of a standard xT cross section.
- Options in the Coating group control the deposition of a protective coating of the intended slice area.

The user interface is shown at left. The following table describes the options in each group. Controls common to each group are listed first, followed by those unique to a particular group.

TABLE 8-16 AUTO S&V USER INTERFACE

Interface Item	Description
Show	Previews all options selected for the Auto S&V job and displays the patterns in the xT user interface. These patterns cannot be manually repositioned as they are deleted before the job is run and redrawn when needed.
Run	Begins the Auto S&V job, using the selected options.
Stop	Aborts the Auto S&V operation following completion of the current step. To interrupt the current process step and exit without completing the job, click STOP in Auto S&V, then STOP PATTERNING in xT.
Phase	Indicates the step being executed (Coating, Rough Cut or Slice).
Processing slice	Indicates the current slice and the total number of slices in the Auto S&V operation.
Current Process	Indicates the process being executed (Milling, SEM imaging)
Progress	Indicates the milling progress.

TABLE 8-16 AUTO S&V USER INTERFACE

Interface Item	Description
Common Options:	
Application	Displays a dropdown menu for selecting an application. The list contains an entry for every application available on the system. If NONE is selected as the application for any particular step, the application skips that step. NONE is the last option in the Application dropdown menu. The factory default application selections are: NONE for the Rough Cut and Coating. *Si* for the Slice tab. Auto S&V performs only the slice step with these settings.
Width (x)	Specifies the pattern width (horizontal on the image) for the selected process step.
Length (y)	Specifies the overall pattern length (vertical on the image) for the selected process step.
Depth (z)	Specifies the pattern depth for the selected process step.
Current (ap)	Displays a dropdown menu for selecting the ion beam current for the specified operation. The list of currents corresponds to the ion beam apertures available on the xT system.
Show/Refresh	Previews the milling pattern for the options selected in a process step.

TABLE 8-16 AUTO S&V USER INTERFACE

Interface Item	Description
Slice tab:	
Slices	Specifies the number of slices to be made in the slice step. The height of each slice is determined by the software dividing the value specified for Length (y) by the number of slices. If the operation calls for more than 100 slices, Auto S&V displays an outline indicating the overall area to be sliced.
Slices/imag.	Specifies the number of slices to be made between images. This option allows several slices to be cut between images.
Take Ion Image Before Start	Specifies that an ion beam image is to be taken before the start of the slice phase.
Coating tab:	
Thickness (z)	Specifies the thickness of the specified protective coating in µm.
Show/Refresh (with slice)	Simultaneously previews the deposition pattern for the protective coating and the milling pattern for the underlying slices.

Using Auto Slice & View

A procedure for using Auto S&V is provided below. All steps are optional.

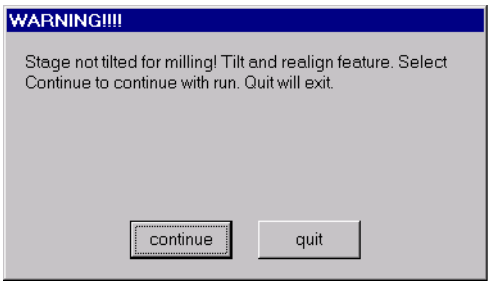
Preparing the xT Dual Beam System

Per normal xT operation, load the sample, navigate to the feature of interest, and center it in the field of view. Set the sample to eucentric height, tilt the stage to the desired setting (usually 52°), and ensure that the ion and electron beams are coincident. Ensure that image shift between ion column aperture settings is minimized.

Optimize electron beam imaging conditions, such as accelerating voltage, detector selection, contrast, brightness, focus, and stigmation. If you use Mode 2 (UHR), you may need to re-establish beam coincidence, due to electron beam shift between search Mode 1 (SRH) and ultrahigh resolution Mode 2 (UHR). Mode 2 (UHR) is recommended for normal Auto S&V operation.

Adjust the magnification for each beam. Set the ion beam magnification so that all patterns are within the field of view. Set the electron beam magnification so that the entire slice area is within the field of view if.

Stage Tilt

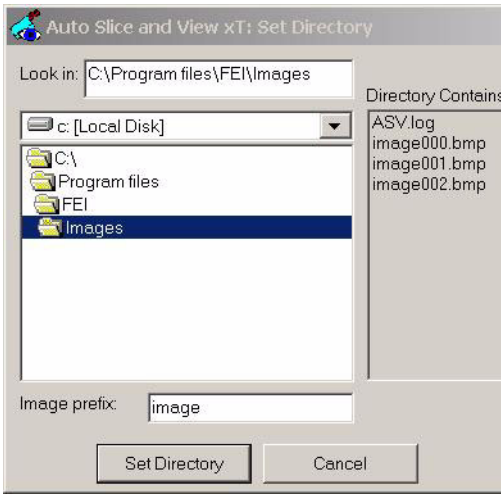

WARNING!!!!
Stage not tilted for milling! Tilt and realign feature. Select Continue to continue with run. Quit will exit.
continue
quit

Auto S&V is designed to run with the stage tilt at 52°, but you can also run it at other stage tilt settings—for example, with pretilted samples.

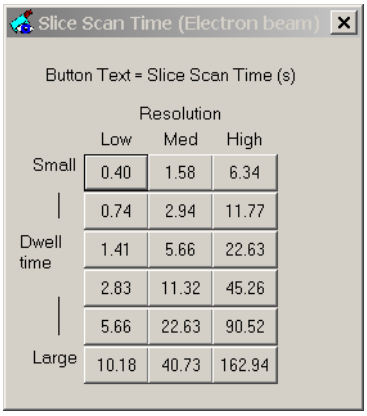
Before running Auto S&V, set the stage tilt to the desired setting. If that setting is not equal to 52°, the application will display a warning.

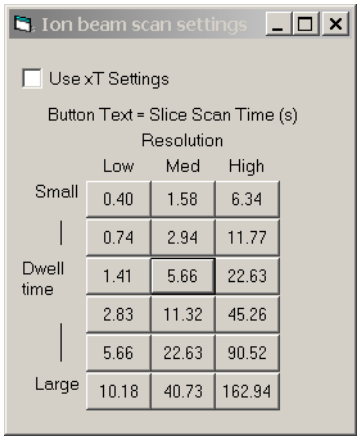
Click CONTINUE to resume the operation at the current stage tilt. Click QUIT to abort the operation.

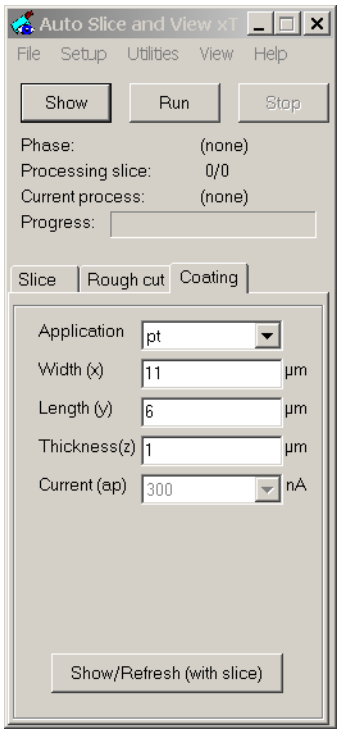
Auto S&V Setup



1. Verify that xT is running and that the system has been prepared for general cross-sectioning and imaging.
2. Select the ion beam as the primary beam.
3. Launch Auto S&V.
4. Select File > Image Save Location to choose a directory where the images will be stored. With the image prefix, you can specify a prefix that identifies the image stack uniquely. In the picture shown, the first file will be called image000.bmp. If you save images to a directory containing bitmaps with the same prefix, Auto S&V prompts for permission to overwrite them.
5. Select the application for all process steps to be performed. If you have previously made the rough cut or deposited a protective coating in xT, set the application for these options to NONE.
6. Select options in the Slice group. The dimensions (including Length, or Z) should be large enough to mill through the feature of interest. The number of slices should be large enough to ensure a good sampling of the volume of interest.







7. If you will use Auto S&V to deposit a protective coating, follow the procedure in *"Coating"*.
8. If you will use Auto S&V to perform the rough cut, follow the procedure in *"Rough Cut"*.
9. Set the beam current. Select a current high enough to mill the sample in a reasonable time, but low enough to guard against sample damage and loss of image resolution. For guidance in setting the beam current, select Utilities > Suggest Currents.
10. Click SHOW to display the pattern to be milled.
    The Auto S&V patterns should align with the feature of interest and cover it. If they do not, recenter the feature with stage moves and repeat steps 6 to 10 if resizing of the pattern is necessary.
11. Select Setup > EBeam Image Scan Parameters to set the electron beam resolution and scan times. The following dialog box appears.
12. Select an appropriate setting. High resolution is recommended for the best image.
13. Select the electron beam as the primary beam and begin imaging. Optimize the image and adjust the magnification to display the entire milling pattern.
14. If you intend to make an ion image before the slicing starts, select Setup > IBeam Image Scan Parameters to set the ion beam resolution and scan times. The following dialog box appears.
15. If you select Use xT Settings, the current ion beam settings from the xT UI are used. Otherwise, select an appropriate setting. High resolution is recommended for the best image.
16. Select File > Save Recipe to save the current parameters to a recipe.

NOTE: Do not attempt to manually reposition milling patterns. Repositioning should be done with stage moves as all patterns are milled or deposited in their default positions and manual repositioning of pattern outlines is ignored at runtime.

Other Patterning Options

The following procedures describe the use of the protective coating and rough cut options. If you have previously performed these steps manually in xT, these procedures are not required.

Coating

1 Select the appropriate options in the Coating group.

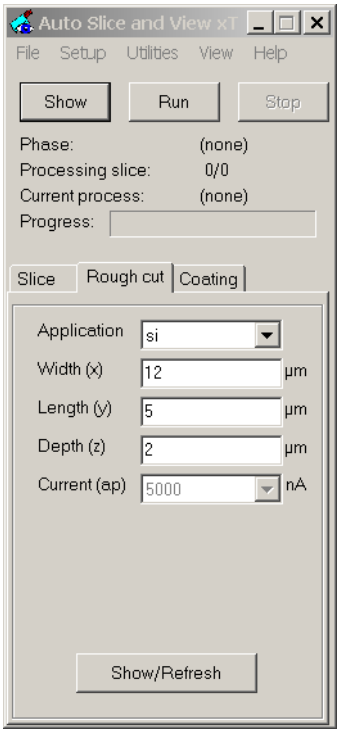
If platinum is not present on your system, substitute another metal, such as tungsten. If no metal is present, do not deposit a protective coating. Set the width and length parameters to deposit a pad that is slightly larger than the area to be sliced. Set the thickness parameter to a value sufficient to protect the surface from unwanted milling—usually 1 µm.

2 Click SHOW/REFRESH (WITH SLICE) to preview your selections. Auto S&V displays the patterns for the protective coating and underlying slices in one view so that you can check their alignment.

3 If the protective coating step requires a different ion beam current than the rough cut or slice steps, deselect the option Disable Aperture Change on the Utilities menu.

NOTE: If you are using the protective coating option, be sure the appropriate GIS is heated before running the application.

Rough Cut



1 Select the appropriate options in the Rough Cut (pre-slice) group.

Set the WIDTH and LENGTH parameters such that Y $\geq$ 1.3 x Z. This proportion will allow imaging of the entire face of the mill at a 52° stage tilt. The rough cut should also be wider than the area to be sliced.

2 Click SHOW/REFRESH to display the pattern to be milled.

3 If the rough cut step requires a different ion beam current than the protective coating or slice steps, deselect the option Disable Aperture Change on the Utilities menu.

4 Using the same beam for the rough cut and slice steps is a simple way of running these processes unattended. To benefit from this feature, however, you must select the Disable Aperture Change option on the Utilities menu.

Milling the Sample

1 Click RUN to initiate the Auto S&V operation.

To abort the operation at any time, click STOP in Auto S&V, then STOP PATTERNING in xT.

2 If you run Auto S&V with the Coating option enabled, the system prompts you to insert the GIS needle and recenter the image. Insert the needle and follow this procedure.

While imaging with the ion beam, recenter the image, using beam shift. Keep live imaging to a minimum to avoid unwanted sample damage.

Grab a second frame to verify the image position relative to the Auto S&V patterns. Repeat this process until the image is correctly centered in the patterns. Click CONTINUE to initiate metal deposition.

3 When the system has finished depositing the protective metal coating, it prompts you to retract the needle and recenter the image. Retract the needle and follow this procedure.

In xT, select the Stage menu> Zero Beam Shift to recenter the image.

Grab one ion beam frame to confirm that the image is centered.

If necessary, fine-tune the image placement, using beam shift.

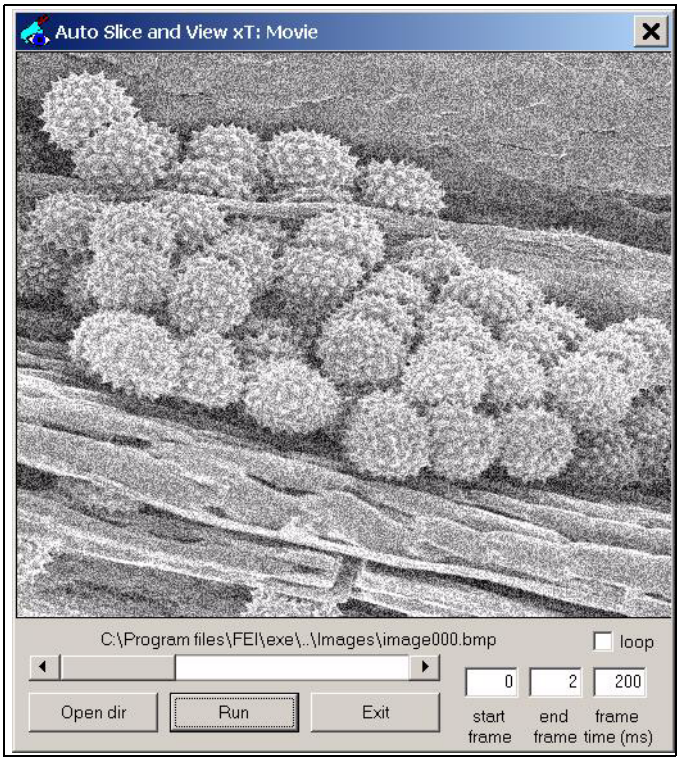
Grab a second frame to verify the image position relative to the Auto S&V patterns. Repeat this process until the image is correctly centered in the patterns.

Click CONTINUE to resume processing the sample.

Viewing the Cross Sections

1. In Auto S&V, select View > Animate to view the images for each cross section. The Movie window appears.

FIGURE 8-8 AUTO SLICE AND VIEW MOVIE



2. Click OPEN DIR to navigate to the directory containing the Auto S&V images.
3. To view a subset of the entire movie, type integers in START and END corresponding to the first and last bitmaps you want to view in the sequence. To run the movie backwards, reverse the order of the integers, typing the higher number in START and the lower number in END.
4. Type an integer in RATE indicating playback speed (in ms per image). The actual playback time may vary slightly depending on available computer resources.
5. Click RUN to begin playing the movie.
6. Alternately, move the horizontal scroll bar or click the arrows at either end to step through the movie one image at a time.
7. 7 When you have finished viewing the images, click EXIT to close the Movie window.

Select LOOP at any time if you want the movie to run continuously.

Exiting the Program

When you have finished milling the sample and viewing the system images, select File > Exit to stop Auto S&V.

Troubleshooting

TABLE 8-17 AUTO S&V TROUBLESHOOTING

Symptom	Question	Solution or Workaround
Movie does not play to the end.	In the Movie dialog box, is the END parameter different from the highest-numbered bitmap in the directory?	Auto S&V automatically counts the images in a directory, but it will stop counting at a gap in the sequence and omit images with higher numbers. If you have removed or deleted a bitmap from that particular directory, restore it, or manually type the correct image number in the END text box.
Patterns are misaligned at different apertures.	Are the apertures used in the recipe aligned to < 1 µm beam shift?	First, align the Ion Beam to all apertures. (See 110 - Ion Aperture Alignment in the Alignment chapter of your system User guide.) If necessary, in Auto S&V, select Setup > Pause Between Sections. A dialog box will display between each recipe segment to allow for manual adjustment. Adjust beam shift and then click OK to dismiss the dialog box.
"Too many points in pattern" error message appears.	Does xT display the "too many points in pattern" error message?	You cannot mill a pattern or combination of patterns that contains more than 1,000,000 points. Possible solutions include: - Decreasing the pattern size - Reducing the beam overlap - Increasing the beam current
"Patterning Error: pitch too small" error message appears.		The minimum pitch is the horizontal field width/4000. You can increase the pitch by increasing the beam current, magnification or blur or decrease the overlap.

Auto TEM (Wizard) Software

Introduction

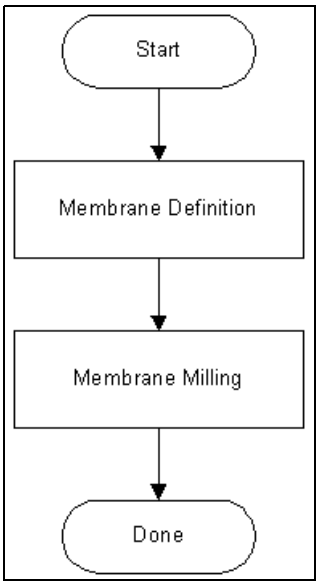
The AutoTEM™ Wizard software automates the process of preparing samples for further examination in a transmission electron microscope (TEM) or other instrument.

This technical note describes:

- Use of AutoTEM™ Wizard
- Preparation of liftout (“plucked”) samples
- Efficient preparation of single or multiple samples
- Script variables
- Troubleshooting procedures

AutoTEM™ Wizard provides a fast and efficient way to prepare TEM samples for analysis. AutoTEM™ Wizard prompts you for the characteristics of one or more TEM membranes, such as width and depth. It then prepares a data file you can run in RunScript or AutoFIB to mill the sample(s).

FIGURE 8-9 TEM SAMPLE PREPARATION PROCESS



During membrane definition, AutoTEM™ Wizard prompts you for the sample width. It then mills a pair of fiducial marks (crosses or circles) that define the width and position of the sample.

After prompting you for further sample characteristics such as depth and thickness, AutoTEM™ Wizard sets parameters for milling and polishing the sample.

In the milling phase, the FIB system mills trenches on both sides of the sample, using the parameters defined by AutoTEM™ Wizard. The system continues milling the edges of the two trenches until the area between them becomes a TEM membrane. An image recognition system uses the fiducials to align the sample after stage moves and beam current changes and to monitor and correct for drift during the mill.

Successful automated preparation can mill samples to 200–100 nm thickness without user intervention. If you want to thin the samples even further, continue milling under manual control.

Samples

Two types of samples can be prepared—prethinned and liftout. A prethinned sample is mechanically polished to about 50 µm or less before being mounted on a TEM grid and placed in the FIB. The automated routines described below can then be used to thin the sample down to approximately 100 nm.

A liftout TEM sample is prepared in a bulk sample (no prior polishing necessary). This sample is created in the DualBeam and then extracted using a glass rod and micromanipulator.

For additional information, see Young, R. J.; Carleson, P. D.; Da, X.; Hunt, T.; Walker, J. F. “High-Yield and High Throughput TEM Sample Preparation Using Focused Ion Beams”, *Proc. ISTFA ’98*, 329 (1998).

Auto TEM Interface

AutoTEM™ Wizard is loaded through RunScript, using the *tem.wsp* workspace.

To start RunScript, click Start > Programs > FEI Company > Applications > RunScript. In RunScript, select File > Open Workspace > *tem.wsp* to open this workspace.

Milling Steps

The sample preparation process typically includes the following steps:

- Protective layer deposition with platinum or other GIS metals (optional)
- Rough milling
- Medium milling
- Fine milling
- Partial cutout of membrane
- Fine polishing

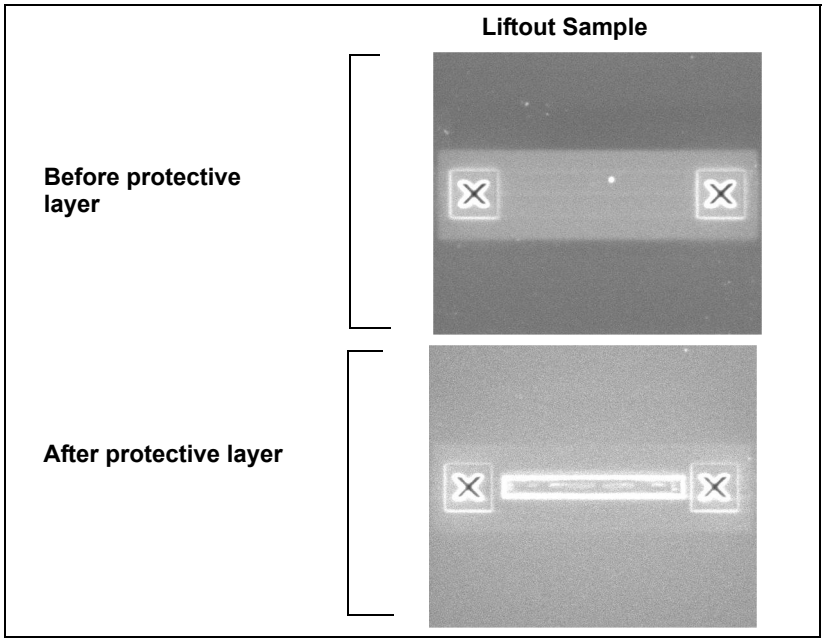
These steps are defined in the data file as steps 1–7. For the default parameters, the order in which the steps are executed is as follows: 1, 2, 4, 5, 3, 5, 6, 7. They are illustrated in the following figures.

NOTE: The values given below for milling time, thickness, and beam current are approximations only.

Step 1 - Protective Layer Deposition

In this step, the dualbeam deposits Pt material to protect the area of interest. This step takes approximately 3 minutes.

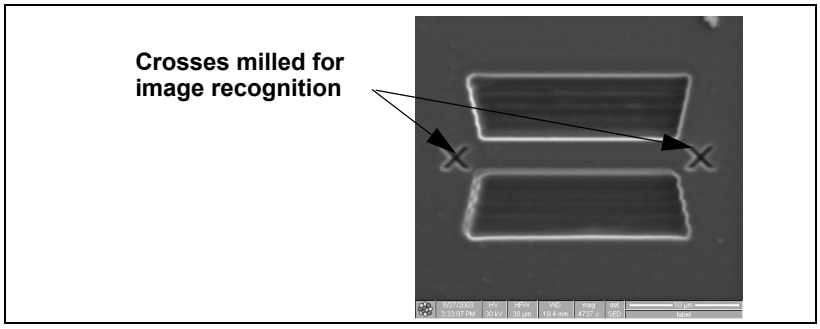
FIGURE 8-10 PROTECTIVE LAYER ON LIFTOUT SAMPLES



Step 2 - Rough Milling

In rough milling, the FIB mills large trenches at maximum beam current.
It takes < 4 minutes. The sample is reduced to a thickness of 4 µm.

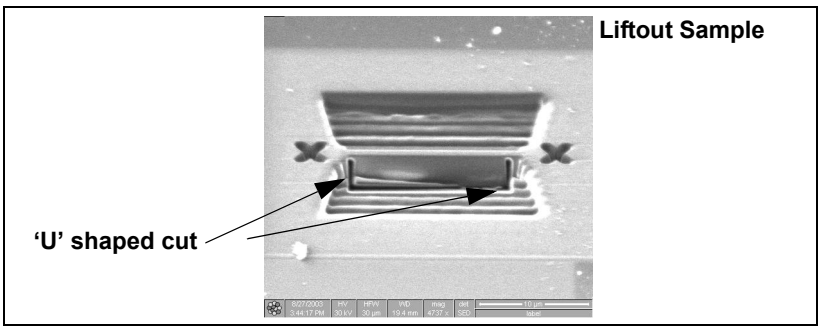
FIGURE 8-11 ROUGH MILLING



Step 3 - Cutout

During cutout, the sample is rotated from 52° to 7° and a U-shaped cut is made to free the sample partially.

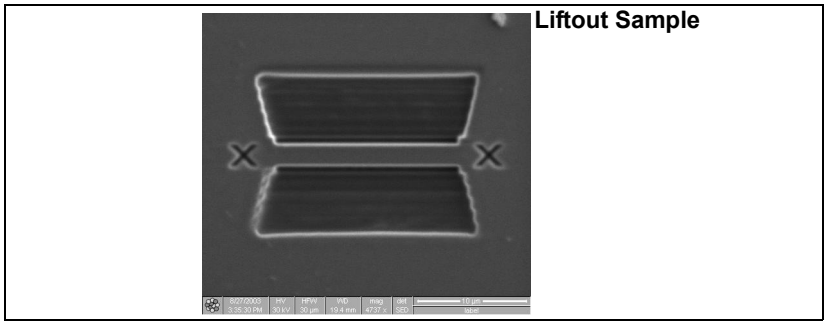
FIGURE 8-12 CUTOUT



Step 4 - Medium Milling

In this step, the FIB mills trench edges on alternating sides of the membrane at a slightly lower beam current and higher magnification. This step takes approximately 2 minutes. The sample is reduced from 4 µm to 2 µm.

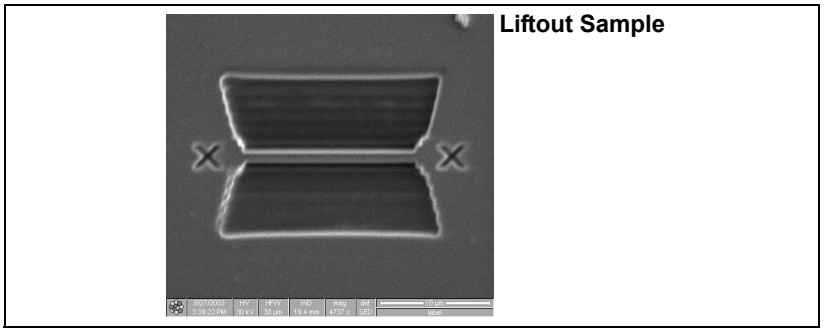
FIGURE 8-13 MEDIUM MILLING



Step 5 - Fine Milling

During fine milling, the FIB continues milling on alternating sides of the membrane. The stage tilts to ensure uniform thickness of sample. This step lasts 3 minutes. The sample is reduced from 2 µm to 1 µm.

FIGURE 8-14 FINE MILLING



Step 6 and 7- Fine Polishing

During fine polishing, the FIB continues milling on alternating sides of the membrane. The stage tilts to ensure uniform thickness of sample.This step lasts 9 minutes. In step 6, the sample is reduced from 1 µm to 0.5 µm. In the final step, the sample is polished to its final thickness. This step takes approximately 3 minutes.

FIGURE 8-15 FINE POLISHING

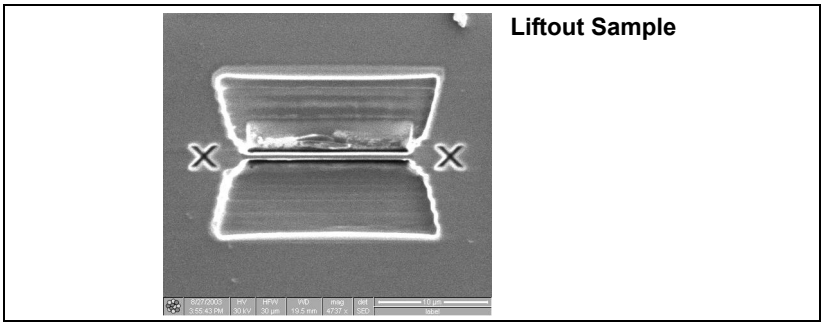


Image Recognition

During sample preparation, the DualBeam system uses the crosses milled into the sample to locate the membrane site, monitor for drift, and correctly place the cuts used to free samples.

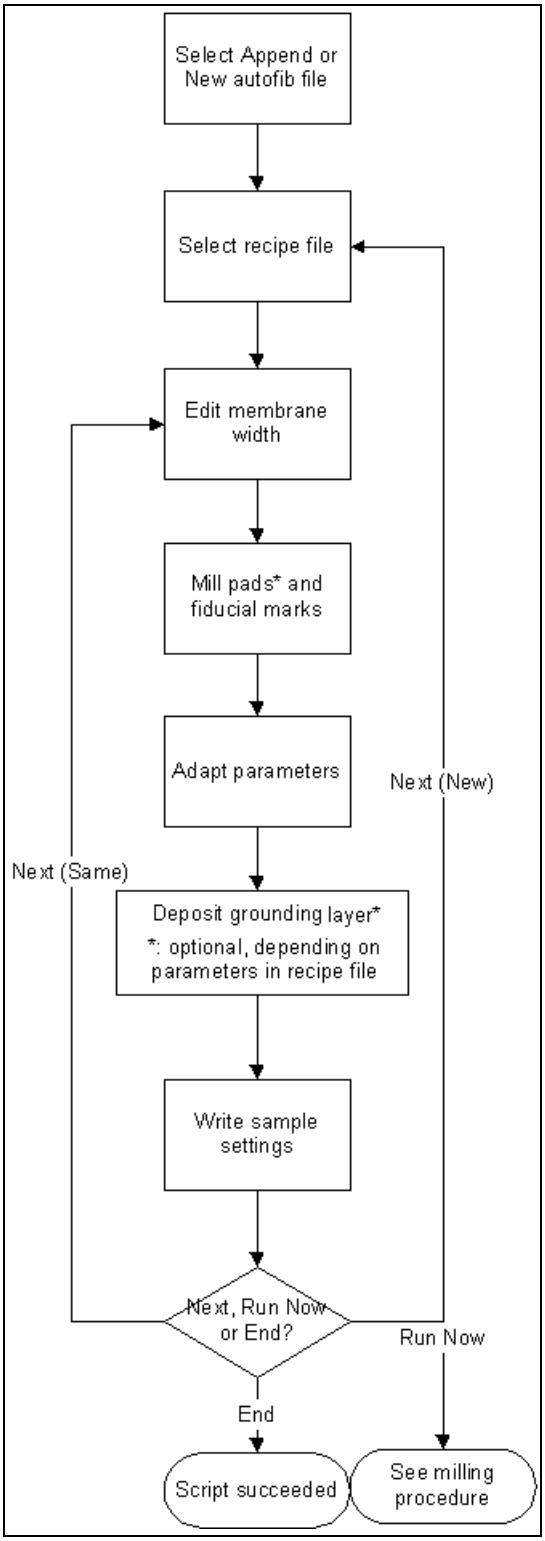
In some cases, the system may have difficulty finding these crosses. If this occurs, the system will first try to find the crosses by:

- Matching the image it finds to other examples stored on the hard drive (in case of an inexact match)
- Performing an Auto Contrast/Brightness routine
- Adjusting the magnification

Sample Definition Process

AutoTEM™ Wizard guides you through the process of siting and defining the sample membrane.

FIGURE 8-16 MEMBRANE DEFINITION PROCESS



Eucentric Height

The sample must be at eucentric height for each membrane that is defined. Begin the membrane setup process by setting the stage to eucentric height.

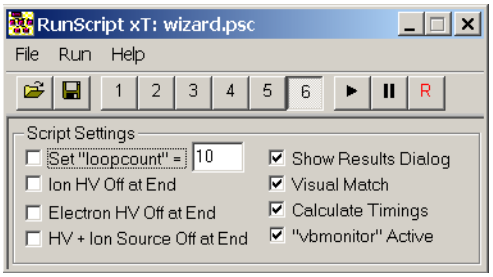
When you set eucentric height, approach the final Z value from the same direction each time. Normally the final move should be in a downwards direction (with the Z value decreasing and the FWD value increasing). This procedure removes any backlash in the Z drive and is particularly important with 50 mm stages.

When you set eucentric height with the ion beam on a DualBeam system, the geometry of the column relative to the sample means that a downwards stage move will cause a feature to move up in the image (with scan rotation at 0°). When you set eucentric height with the electron beam on a DualBeam system the feature will move down when the stage moves down.

Running Auto TEM

1 Start RunScript.

2 Click OPEN WORKSPACE, navigate to the subdirectory containing the TEM scripts, and open the workspace file *TEM.wsp*.



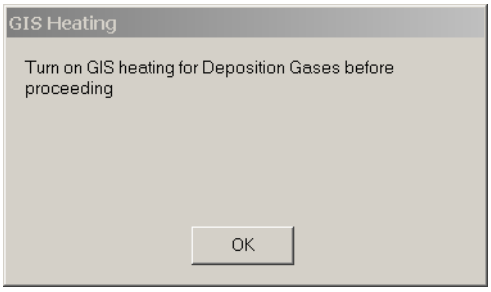
The RunScript interface appears as shown here, with the correct check boxes automatically checked.
Button 6 is used for the AutoTEM™ Wizard program. Other numbered buttons are used for the data files created by AutoTEM™ Wizard.

3 Select Button 6 and press PLAY to begin the TEM preparation process.

The balance of this section reviews the AutoTEM™ Wizard dialog boxes in sequence, with a full explanation of available options.

Membrane Setup

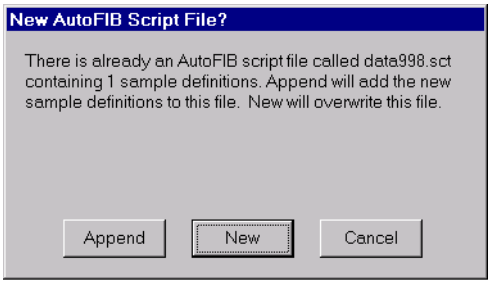
Preliminary Steps



After you select Button 6 and click PLAY, the system displays a dialog box that prompts you to turn on GIS heating for the necessary beam chemistries.

If you have not already done so, turn on the heat to the gas injectors. If the gas injectors are not properly heated, the FIB will mill material instead of depositing material.

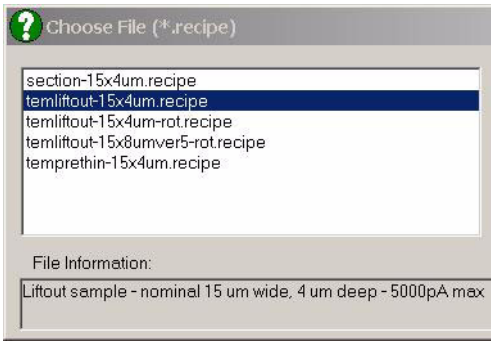
NOTE: If you are using tungsten deposition, contact FEI Customer Service to configure the AutoTEM™ Wizard.

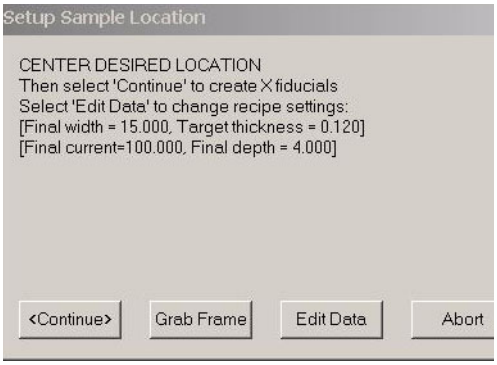

New AutoFIB Script File?
There is already an AutoFIB script file called data998.sct containing 1 sample definitions. Append will add the new sample definitions to this file. New will overwrite this file.
Append
New
Cancel

Next, AutoTEM™ Wizard prompts you to create a new AutoFIB script file or append data to an existing one. The script file (called *data998.sct*) contains the information AutoFIB requires to move between multiple positions and mill multiple TEM sections.

If a file containing data for the TEM sections already exists, the system will display a dialog box prompting for confirmation of action.

Click APPEND to add new positions to an existing file or NEW to create a new file. A file open dialog is shown in which you can select a recipe file (recipe files are created by FEI).




Setup Sample Location
CENTER DESIRED LOCATION
Then select 'Continue' to create X fiducials
Select 'Edit Data' to change recipe settings:
[Final width = 15.000, Target thickness = 0.120]
[Final current=100.000, Final depth = 4.000]
<Continue>
Grab Frame
Edit Data
Abort

AutoTEM™ Wizard then creates a data file for each defined membrane. The file name is always *dataN.ini*, where *N* equals the position number of the defined membrane. The data file is inserted into the directory where AutoTEM™ Wizard is running.

The system then displays a representation of the TEM membrane and the crosses used for image recognition. The sample must be at eucentric height for each membrane that is defined.

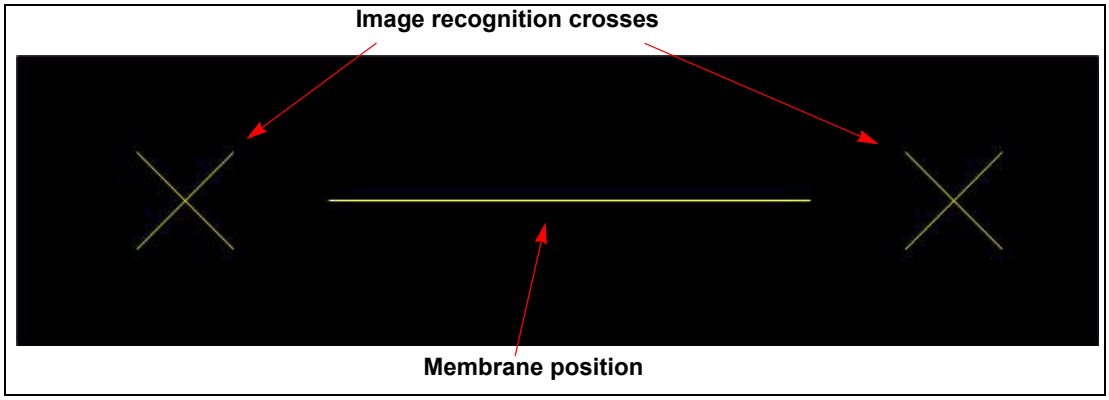
Specifying the Sample Parameters

In the next dialog box you can edit the sample parameters shown in the following table.

TABLE 8-18 LOCATION PARAMETERS

Parameter	Description
Finalwidth	Desired width of TEM section. Long sections (over 20 µm) may exhibit some warping or stress, depending on the material and the thickness of the membrane.
Targetthickness	Desired nominal thickness of the membrane in µm
Finaldepth	Approximate final depth of the mill, in µm
Finalcurrent	The current used in the last milling step 7.

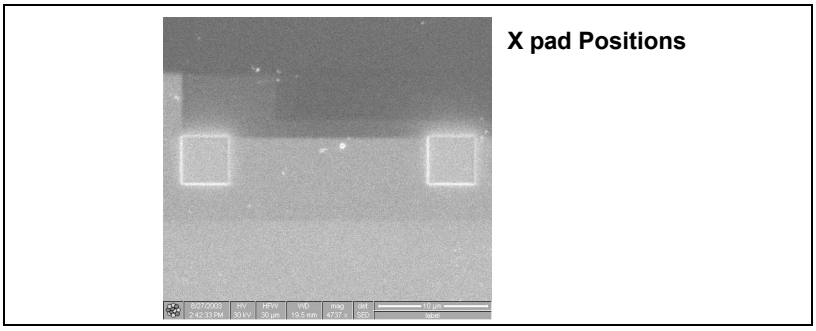
FIGURE 8-17 REPRESENTATION OF TEM MEMBRANE AND IMAGE RECOGNITION CROSSES



If you select **Edit Data**, you can edit the parameters of previous table.

If you select **Continue**, the wizard will start depositing 2 square Pt pads in which the crosses are to be milled.

FIGURE 8-18 X PAD DEPOSITION



Adjusting Sample Parameters

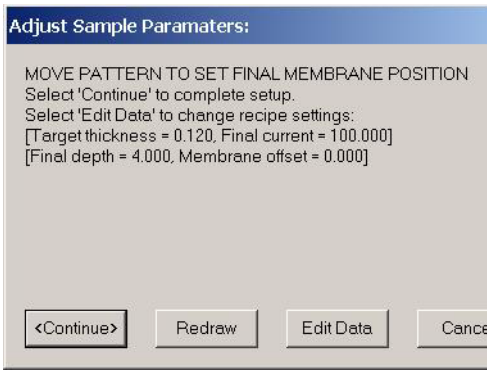
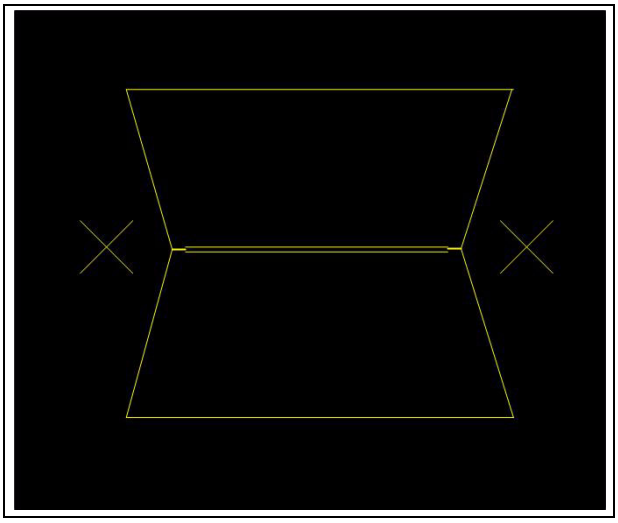
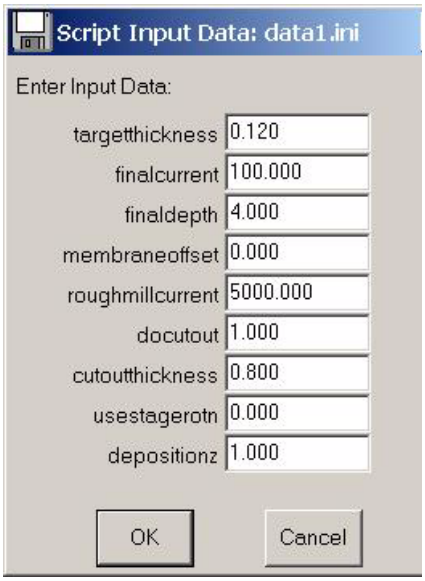
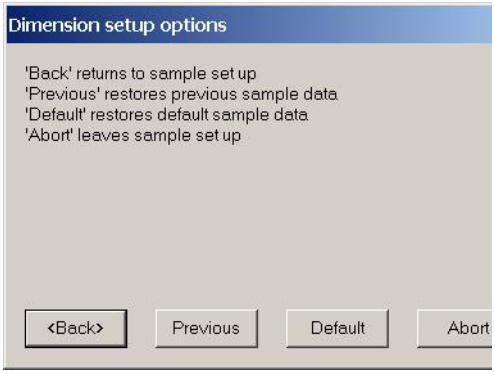

Adjust Sample Paramaters:
MOVE PATTERN TO SET FINAL MEMBRANE POSITION
Select 'Continue' to complete setup.
Select 'Edit Data' to change recipe settings:
[Target thickness = 0.120, Final current = 100.000]
[Final depth = 4.000, Membrane offset = 0.000]
<Continue>
Redraw
Edit Data
Cance

FIGURE 8-19 MEMBRANE POSITIONING







A diagram onscreen shows the area to be milled and a dialog box appears. You can choose to edit the parameters of TABLE 1 *"Location Parameters"* (except finalwidth) and TABLE 2 *"Liftout Parameters"* and you can reposition the membrane interactively by drag-and-dropping the membrane pattern. For prethinned samples, you can also drag-and-drop the outer edges of the rough mill area.

Choose from the following options:

- Continue proceeds with the sample preparation process.
- Redraw to display the result of changing the membrane position interactively.
- Edit Data shows an Input dialog box, where you can change sample preparation parameters. The parameter names displayed in the dialog box correspond to the names of the script variables, which are defined in tables 1 and 2 *"Location Parameters"* and *"Liftout Parameters"*.

Options shows the Dimension setup options dialog with the options Back, Previous, Default and Abort.

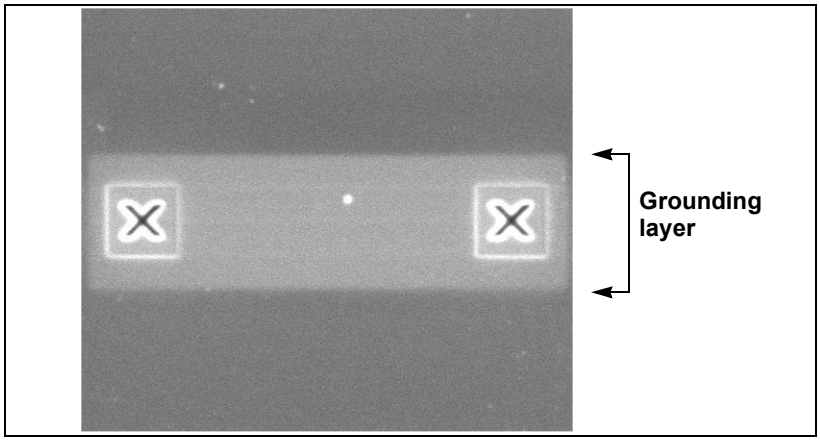
TABLE 8-19 LIFTOUT PARAMETERS

Parameter	Description
Membrane offset (membraneoffset)	Offset between the actual membrane section and the horizontal axis of the X-shaped fiducial marks, in µm. Use a positive number to locate the membrane above the crosses, a negative number to locate it below them. Use **membraneoffset** when the feature of interest is so near the sample edge that it prevents proper milling of the crosses. In such a case, place the crosses at a location suitable for image recognition, then use a value for **membraneoffset** to situate the membrane at the desired location. You can also use **membraneoffset** to adjust the membrane position when the crosses are incorrectly placed in relation to the feature of interest.
Rough mill current (roughmillcurrent)	The current used in step 2.
Do cutout (docutout)	If docutout=1, the cutout step will be performed. If docutout=0, no cutout step is performed.
Cutout thickness (cutoutthickness)	The minimum thickness below which the cutout step is performed. As long as the sample thickness is larger than this value, the cutout step is skipped.
Use stage rotation (usestagerotn)	Determines whether the stage rotation value is saved in the data file. Set to 1 to save this value. Set to 0 if rotation is not necessary for sample placement. In some cases, backlash in the stage can cause small positioning errors when the rotation value is saved.
Depositionz	The thickness of the deposition layer, in µm.

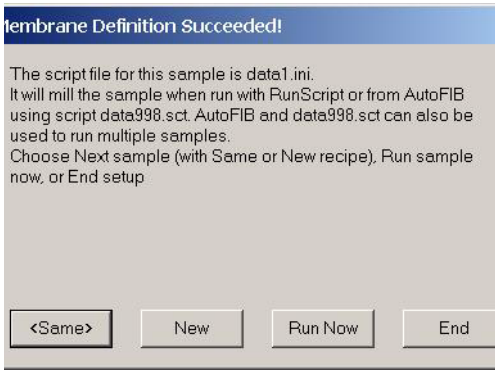
Depositing a Grounding Layer

Next, the AutoTEM™ Wizard deposits a very thin platinum grounding layer over the area of interest. This layer can improve image recognition in areas where there are topographical and material differences across the width of the membrane.

FIGURE 8-20 GROUNDING LAYERS



Completing the Membrane Setup


lembrane Definition Succeeded!
The script file for this sample is data1.ini.
It will mill the sample when run with RunScript or from AutoFIB using script data998.sct. AutoFIB and data998.sct can also be used to run multiple samples.
Choose Next sample (with Same or New recipe), Run sample now, or End setup
<Same>
New
Run Now
End

When you have completed the setup for each individual membrane, the system displays the 'Membrane Definition Succeeded' dialog box.

Press SAME to continue the setup process and define another membrane with the same recipe. Press NEW to continue the setup process and define another membrane with another recipe. Press RUN NOW to start milling the membrane immediately. Press END to complete the setup process. The system confirms completion of the membrane setup.

When you have defined all membranes, the system will create a data file for each defined membrane and an AutoFIB file for the complete set of membrane definitions.

Sample Milling

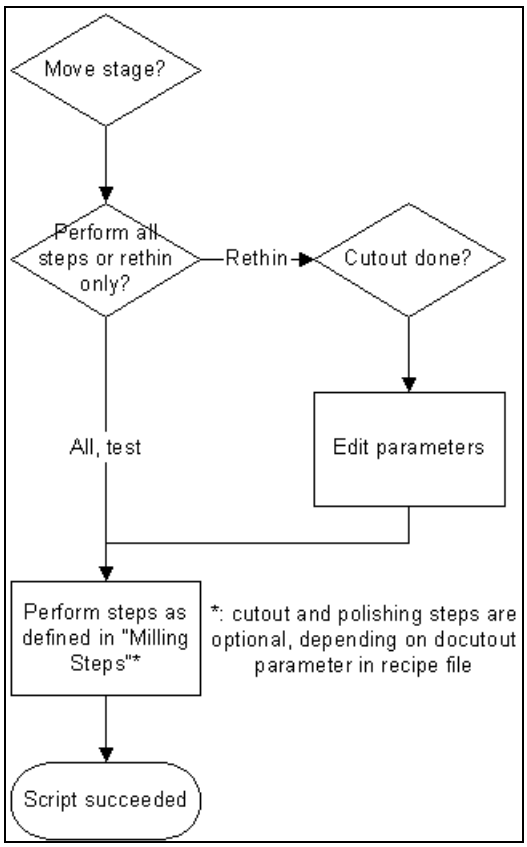
When membrane definition is complete and the crosses have been milled, you can begin milling the TEM membrane(s). Proceed in one of two ways:

1. Press RUN NOW in the "Membrane Definition Succeeded' dialog box.
2. Run each data file using RunScript. This may be useful if you are milling only one membrane at a time. Using RunScript, you can fully automate the milling of a single membrane, or
3. Run the *data998.sct* file using AutoFIB. This process is completely hands-free and is useful for overnight milling or milling multiple membranes without any user intervention.

Running the Data File from RunScript

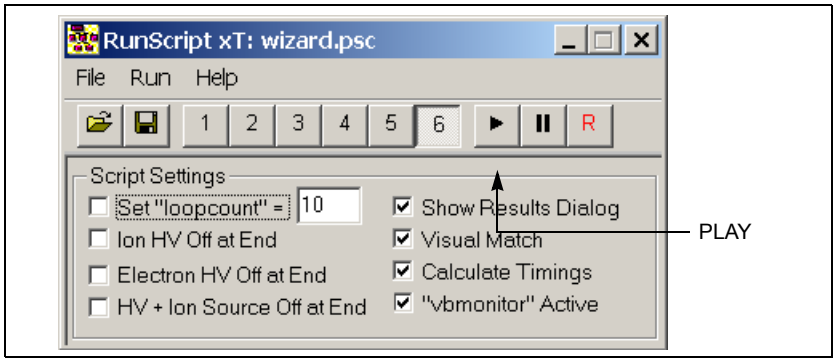
When you prepare a defined membrane using RunScript, you have the option of beginning with the main milling steps or proceeding directly to the polish step. This workflow is illustrated in the following figure.

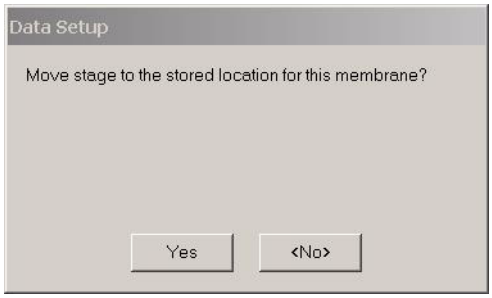
FIGURE 8-21 MEMBRANE MILLING PROCESS USING RUNSCRIPTS


Move stage?
Perform all steps or rethin only?
Rethin
Cutout done?
All, test
Edit parameters
Perform steps as defined in "Milling Steps"*
*: cutout and polishing steps are optional, depending on docutout parameter in recipe file
Script succeeded

To begin, select the button that corresponds to the membrane definition, then press PLAY. For example, in the figure below, Button 1 corresponds to the *data1.ini* file for the first membrane defined in the setup process.

FIGURE 8-22 DATA1.INI FILE



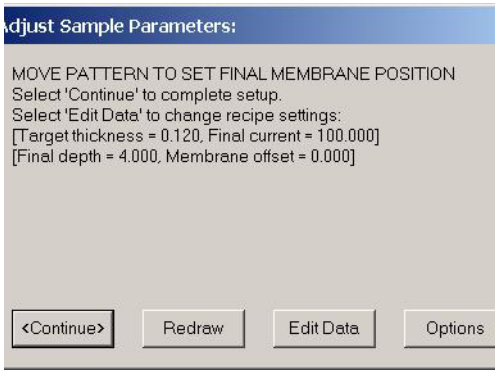


The system prompts you for permission to move the stage to the location saved for this membrane.

Click YES if it is necessary to move the stage to view the crosses for the membrane. Click NO if the stage is already at the appropriate location and the crosses are onscreen.

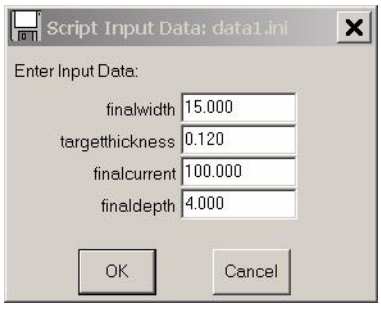
The system then asks you if it should perform all milling steps or polishing only.

Click ALL to begin with the protective platinum deposition (if specified) and proceed to rough milling. Click RETHIN to finish a previously milled sample or to cut free a partly milled membrane; the system will ask you if the cutout step has been performed already.


djust Sample Parameters:
MOVE PATTERN TO SET FINAL MEMBRANE POSITION
Select 'Continue' to complete setup.
Select 'Edit Data' to change recipe settings:
[Target thickness = 0.120, Final current = 100.000]
[Final depth = 4.000, Membrane offset = 0.000]
<Continue>
Redraw
Edit Data
Options

If you select Yes, the Adjust Sample Parameters dialog will be shown and you have the option to change some parameters of tables 1 and 2 "*Location Parameters*" and "*Liftout Parameters*" and two extra parameters: uppery and lowery. Uppery is the distance from the membrane to the upper edge of the milling pattern, in µm. This value must overlap the current upper membrane edge. Lowery is the distance from the membrane to the lower edge of the milling pattern, in µm. This value must overlap the current lower membrane edge.

Edit these values if desired, or change them interactively by drag-and-dropping the membrane (for membrane offset) or resizing the box surrounding the membrane (for uppery and lowery).



If you select no, there is an extra parameter you can edit: startatcutout.

If you enter 1, the milling will resume with the cutout step.

The amount of time required to mill the TEM membrane will vary depending on the dimensions of the cut. A typical liftout membrane that is 15 µm wide and 6 µm deep will take about 30 minutes to mill.

Throughout the milling process, the system will use the crosses to realign the sample. The system will also use these marks for alignment while cutting the sample free, when the stage is tilted to 45°. Image recognition is less reliable when the stage is tilted, and sample topography can also complicate the situation. In some cases, image recognition may fail.

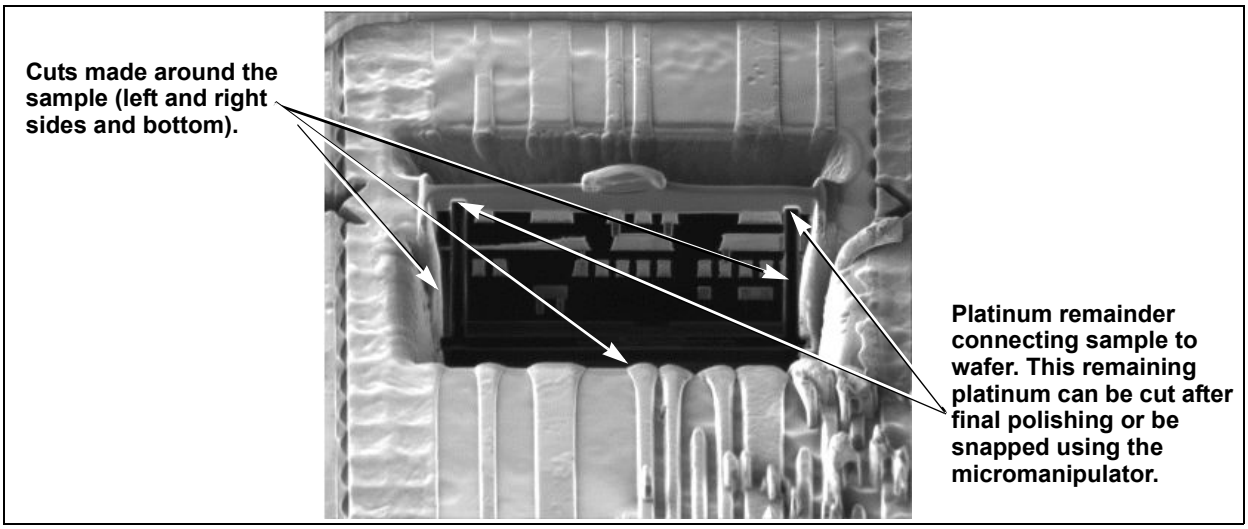
If image recognition fails, the system will display the 'Match failed' dialog box.

Try adjusting focus, contrast, brightness, or stage position, then press RETRY. If failure still occurs, manually realign the sample and click CONTINUE to proceed. To end the script without milling the sample, press END.

NOTE: In RunScript, you can suppress these prompts by editing nodialog in the *dataN.ini* file. Set this variable to 1, and the script will run without prompts as it would in AutoFIB.

When AutoTEM™ Wizard runs successfully, it will produce a sample like the one shown below.

FIGURE 8-23 LIFTOUT SAMPLES VIEWED AT 7°


Cuts made around the sample (left and right sides and bottom).
Platinum remainder connecting sample to wafer. This remaining platinum can be cut after final polishing or be snapped using the micromanipulator.

When you have finished preparing a TEM section, you can run another data file, and RunScript will drive to that stage location.

Running the Data File from AutoFIB

Use AutoTEM™ Wizard to define multiple membranes, then run the data file using AutoFIB.

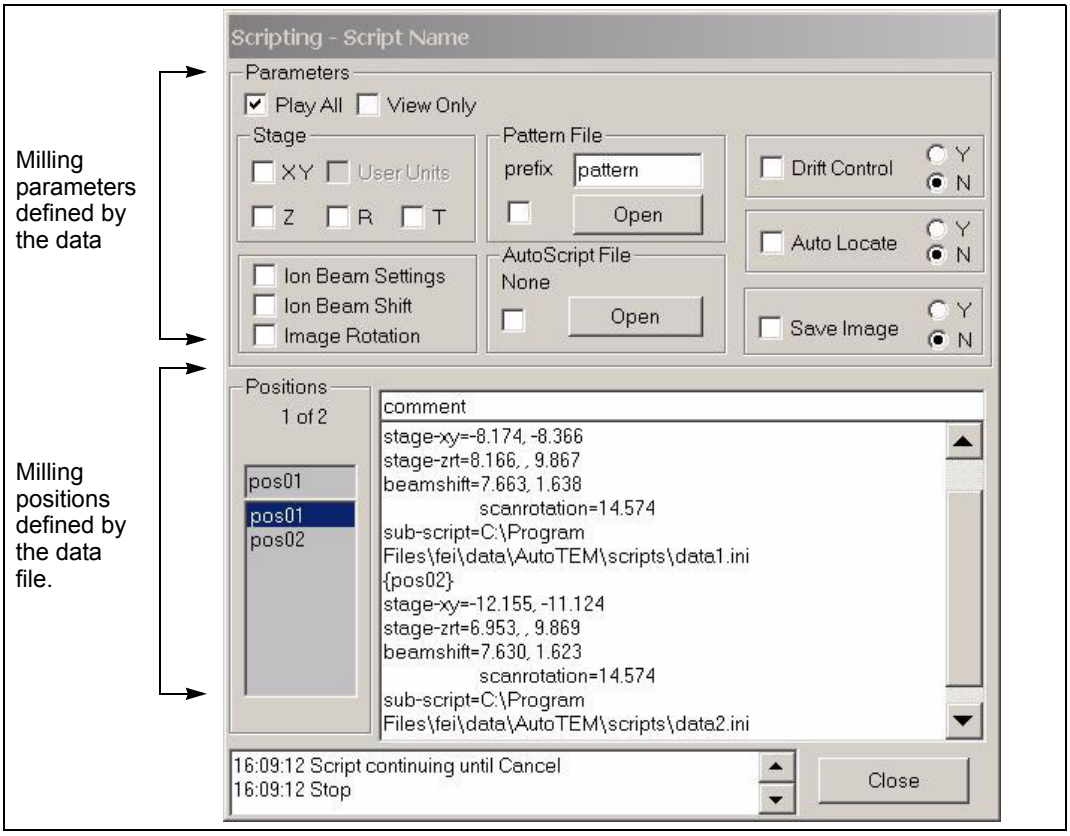
To run AutoFIB, click START > Programs > FEI Company > Applications > AutoFIB. The AutoFIB interface will appear.

FIGURE 8-24 RUN AUTOFIB

Select File > Open and load the file *data998.sct*.

The AutoFIB Scripting dialog box will appear in a configuration similar to that shown below.

FIGURE 8-25 AUTOFIB SCRIPTING DIALOG BOX



Do not select the options DRIFT CONTROL or AUTO LOCATE. When run under AutoFIB, the TEM preparation script automatically takes care of drift control and image recognition. The data file *data998.sct* will automatically select the proper options when loaded into AutoFIB. Once you have loaded the data file, no further action is necessary.

You may want to enable visual matching within AutoFIB or have the beam shut off automatically at the end of milling. These commands are available on the AutoFIB Options menu.

When scripts are run through AutoFIB, no prompts are given during the process. If image recognition fails, the system will simply proceed to the next membrane or end the script if no other membranes are defined. In such a case, you must correct the error that caused the image recognition failure, then rerun the script on the positions that failed.

NOTE: If prompted to save the data file, say NO to avoid overwriting the newly created file.

Sample Files

The following data file represents a typical membrane definition produced by AutoTEM™ Wizard.

```
# data file created by 'vbmakeini': 10/29/2004 4:04:35 PM
      targetthickness=0.120
      finalcurrent=100.000
      finaldepth=4.000
      centeroffset=0.000
      roughmillcurrent=5000.000
      uppery=6.400
      lowery=6.400
      taperangle=28.000
      docutout=1.000
      cutoutthickness=0.800
      usestagerotn=0.000
      depositionz=1.000
      dovlowmagalign=0.000
      makevlowmagbmp=0.000
      if (dimsetupreadout=1) goto end
      finalwidth=15.000
      restartthickness=1.000
      position=1.000
      wizstagetilt=9.867
      test=0.000
      dooutline=0.000
      confirmcutout=0.000
      rethin=0.000
      startatcutout=0.000
      donecutout=0.000
      nodialog=0.000
      run systemvalues.ini
      recipedefaults=1
      run temliftout-15x4um.recipe
      writesampledata=2
      run temliftout-15x4um.recipe
      calcvalues=2
      run temliftout-15x4um.recipe
      run setprimaryionbeam.sps
      if (posnum>0) goto inautofib
      setbeamrot 14.574
      run stageprompt.sps
      if (dresult=1) stagemove xyzt,-8.174,-8.366,8.166,9.867
      run polishprompt.sps
      if (dresult=0) goto end
      goto noautofib

inautofib:

      nodialog=1
      run autofib.ini
```

The following script file contains the information AutoFIB requires to move between multiple positions and mill multiple TEM sections. It is also produced by AutoTEM™ Wizard.

```
# data file created by 'vbmakeini': 10/29/2004 4:04:36 PM
{pos01}
stage-xy=-8.174, -8.366
stage-zrt=8.166, , 9.867
beamshift=7.663, 1.638
```

```
      scanrotation=14.574
sub-script=C:\Program Files\fei\data\AutoTEM\scripts\data1.ini
{pos02}
stage-xy=-12.155, -11.124
stage-zrt=6.953, , 9.869
beamshift=7.630, 1.623
      scanrotation=14.574
sub-script=C:\Program Files\fei\data\AutoTEM\scripts\data2.ini
```

Script Variables

This section documents the variables used in the TEM preparation scripts. As an alternative to the setup process, you can edit the scripts directly using a text editor.

Two files contain variables you can edit:

- A *recipe file* contains all values necessary for the main TEM preparation script to run successfully.
- *DialogDefaults.ini* contains the default values for all settings listed in the input data boxes.

In addition, *SystemValues.ini* contains variables used in the membrane definition process. These variables are ordinarily set by FEI Customer Service.

! **CAUTION! To prevent data loss, make copies of all your script files before editing them.**

The variables are listed in their order of appearance in the respective files. Do not change parameters other than those mentioned in the tables.

TABLE 8-20 RECIPE FILE PARAMETERS

Variable Name	Default Value	Purpose
test	0	If test=1 then the Wizard does not mill or clear patterns. If test=2 then will also prompt to clear patterns at end of milling steps. This value also appears in each data<n>.ini
dooutline	0	Determines whether series of full milling patterns are drawn, or just an outline box (or series of lines) - the outline mode(s) are used for testing purposes. dooutline=0 normal mill boxes dooutline=1 outline box of dimensions in recipe dooutline=2 outline box adjusted in y for 'adjustvalues'. Normally dooutline =0. This value also appears in each data<n>.ini
nodialog	0	If nodialog=1, the wizard will not prompt at a failed match AND will not prompt to place cuts in step 5. Normally for RunScript nodialog=0. For AutoFIB, nodialog=1. This value also appears in each data<n>.ini

TABLE 8-20 RECIPE FILE PARAMETERS

Variable Name	Default Value	Purpose
confirmcutout	0	RunScript only: If confirmcutout=1 then a confirmation from user is requested to do a cutout in step 5. If confirmcutout=0 no user confirmation is requested if matching succeeds. Normally, confirmcutout=0 in RunScript. In AutoFIB mode, a confirmation is never asked. This value also appears in each data<n>.ini
docutout	1	If docutout=1 then attempt the cutout step 5 if the thickness range is correct. If docutout=0 the wizard stops at the cutout step 5 and exits (go to next sample if AutoFIB). This value also appears in each data<n>.ini
targetthickness	0.2	Default target thickness, see TABLE 1, "*Location Parameters"*. This value also appears in each data<n>.ini
minthicknes	0.1	Minimum allowed targetthickness in edit dialogs
maxthickness	6	Maximum allowed targetthickness in edit dialogs
usestagerotn	0	Default stage rotation usage, see TABLE 1 "*Location Parameters"*. This value also appears in each data<n>.ini
donecutout	0	Initially 0, it is set to 1 once the cutout step has been done. This value also appears in each data<n>.ini
startatcutout	0	If startatcutout=1, the cutout step 5 is done next (i.e. the sample already has the correct width). This value also appears in each data<n>.ini
rethin	0	Rethin=1 means starting partway through (bypass deposition step 1 and rough milling step 2). This value also appears in each data<n>.ini
pluck	0	Not used. This value also appears in each data<n>.ini
finaldepth	6	Default target finaldepth, see TABLE 1 "*Location Parameters"*. This value also appears in each data<n>.ini
mindepth	3	Minimum allowed finaldepth in edit dialogs.

TABLE 8-20 RECIPE FILE PARAMETERS

Variable Name	Default Value	Purpose
maxdepth	20	Maximum allowed finaldepth in edit dialogs.
defaultfinalwidth		Default target finalwidth, see TABLE 1 "*Location Parameters"*. This value also appears in each data<n>.ini
minwidth		Minimum allowed defaultfinalwidth in edit dialogs.
maxwidth		Minimum allowed defaultfinalwidth in edit dialogs.
membraneoffset		Default target membraneoffset, see TABLE 1 "*Location Parameters"*. This value also appears in each data<n>.ini
minmembraneoffset		Minimum allowed membraneoffset in edit dialogs.
maxmembraneoffset		Maximum allowed membraneoffset in edit dialogs.
crossz		Depth of fiducial crosses.
circlez		Not used.
setupioncurrent		Current used to interactively set up a TEM prep site, in A.
crossioncurrent		Current used to mill crosses, in A.
depositionz		Thickness of Pt deposition layer for protective coating in step 1. If 0, no protective coating will be deposited. This value also appears in each data<n>.ini
groundgis		GIS number of grounding GIS
groundz		Thickness of Pt deposition layer for grounding layer in preparation step.
padz		Thickness of Pt deposition layer for pads in preparation step.
padouterz		Thickness of Pt ground layer for left pad in preparation step when dovlowmagalign=1.
depthcorrection	1	Applies to milling steps. For materials other than the selected application, a correction factor <>1 may be needed. Use >1 for samples harder than the application, use <1 for softer samples. This value also appears in each data<n>.ini

TABLE 8-20 RECIPE FILE PARAMETERS

Variable Name	Default Value	Purpose
dovlowmagalign	0	Lowmag align feature. If dovlowmagalign is =1 then a circle is milled next to the left cross for recognition at low magnification. Normally dovlowmagalign=0. This value also appears in each data<n>.ini
makevlowmagbmp	0	if makevlowmagbmp =1 then make a separate .bmp for recognition at low magnification, if makevlowmagbmp=0 then use the standard .bmp. This value also appears in each data<n>.ini
vlowmagcirclerad		Radius of fiducial circle for recognition at low magnification.
vlowmagcirclez		Depth of fiducial circle for recognition at low magnification.
dorcg	1	Used during setup. If dorcg=1, matching is used to recenter crosses. If dorcg=0, matching is not used, and if dorcg=-1, the user is prompted to do matching to recenter crosses.
dogrounding	1	Used during setup. If dogrounding =1, a grounding layer is deposited. If dogrounding =0, no grounding layer is deposited., and if dogrounding =-1, the user is prompted to deposit a grounding layer.
showeditfirst	0	Used during setup. If showeditfirst=1, the edit dialog is shown before graphics of the sample. Normally, showeditfirst=0.
cutbottom	1	If cutbottom=1, the bottom of the U will be milled in the cutout step 5.
cutleftside	1	If cutleftside=1, the left side of the U will be milled in the cutout step 5.
cutrightside	1	If cutrightside=1, the right side of the U will be milled in the cutout step 5.
cutwidth	0.3	The width of the legs of the U-cut in step 5.
surfacemargin	0.42	The distance of the tips of the U to the surface in step 5.

Initial Use

Before using AutoTEM™ Wizard for the first time, follow these steps:

NOTE: FEI Customer Service ordinarily performs this procedure during installation.

Start RunScript.

Load the workspace file *TemCalibrate.wsp*. With buttons 1-6, various calibration routines can be run. These are:

- **1. setconfiguration.psc.** In this script, the following parameters can be viewed or set:

  dualbeam: 0 = FIB, 1 = dualbeam

  ioncolumn: 0 = prelens, 1 = magnum, 2 = sidewinder

  deltac: not used, value = 0

  beamcheck: not used, value = 1

  usemillcheck: not used, value = 0

  donotmatch: 0 = off-default, 1 = active (for simulator use)

The values can be written to registry automatically. Press Play to view/edit the parameters.

- **2. setcalibration.psc.** In this script, the following calibration parameters can be viewed/edited:

  detscaler: contrast/brightness correction factor for the current detector. This value does not have to be edited if calibration 4 has been done.

  maxiap: the number of ion beam apertures. This value is obtained automatically during first startup and does not have to be edited.

A list of GIS names and corresponding GIS ports, these are obtained automatically during first startup and do not have to be edited, for example:

ptgis: the port number of the pt gis

yoffpix: a correction term for the difference between milling and cross image recognition in y. This value is written by calibration 5.

xoffpix: a correction term for the difference between milling and cross image recognition in x. This value is written by calibration 5.

yoffpixcircle: a correction term for the difference between milling and circle image recognition in y. This value is written by calibration 5.

yoffpixslow: a correction term for the difference between milling and image recognition at slow scan speeds in y. This value is written by calibration 5.

bscalibx: an overall beam shift correction factor in x. This value is written by calibration 3.

bscaliby: an overall beam shift correction factor in y. This value is

written by calibration 3.

A list of GIS related names and corresponding GIS needle beamshift correction terms, for example:

bsxpt: the beam shift correction term for pt GIS in x

bsypt: the beam shift correction term for pt GIS in y

These values are written by calibration 3.

bsx45tilt: the beam shift correction term in x for the cutout step, at 45 degree tilt with respect to the ion beam. This value is written by calibration 3.

bsy45tilt: the beam shift correction term in y for the cutout step, at 45 degree tilt with respect to the ion beam. This value is written by calibration 3.

Iondethcfactor: not used

Iondethbfactor: not used

Depthcorrection: a correction factor that takes account of softer (<1) and harder (>1) materials then the material in the application file. This value has to be entered manually.

Thicknesscorrection: a correction factor that can tune the resulting membrane thickness if it deviates from the user-defined value. Use a value <1 to correct for membrane thicknesses larger than initially defined. This value has to be entered manually.

Press Play to view these parameters.

- **3. Setbeamshiftalignment.psc**: In this script, three calibrations can be performed,

  1. “Calib”: Overall beam shift correction factors: bscalibx, bscaliby
  Press Play, then Press Calib to start the calibration. Find (or mill) unique, high-contrast features and adjust the view so they are centered in the screen at 5000–1000 X magnification. The values for bscalibx, bscaliby can be written to the registry automatically.

  2. “GIS Shift”: GIS needle beam shift correction terms: bsxpt, bsypt in example above
  Press Play, then Press GIS Shift to start the calibration. Find (or mill) unique, high-contrast features and adjust the view so they are centered in the screen at 5000–1000 X magnification. Each configured GIS is inserted in turn after user confirmation, the calibrated values can be written to the registry automatically.

  3. “Tilt Shift”: Tilt beam shift correction terms: bsx45tilt, bsy45tilt
  Press Play, then Press Tilt Shift to start the calibration. Set the stage to eucentric height with the electronbeam, center a feature with the stage at 52 degrees, switch to the ion beam, select the aperture for 300 pA current, and center the same feature. Then press Continue. The stage will be tilted to 7 degrees. With beamshift, correct the tilt induced shift. The calibrated values can be written to the registry automatically.

- **4. SetdetectorCBvalue.psc**: In this script, the contrast and brightness correction factors per detector can be determined.

Press Play to start the calibration. The script sets a current (the current with which the fiducials are milled). Optimize the Contrast/Brightness settings of the image at this current. Then, the script sets a higher current (the rough mill current). Optimize the Contrast/Brightness settings again. The calibrated values are written to the registry automatically. After the calibration, press End and run again for another detector.

- **5. SetMillPositionCalibs.psc**: In this script, the final membrane and circle millpositions with respect to fiducials found by image recognition can be calibrated: xoffpix, yoffpix, yoffpixslow, yoffpixcircle.

  Press Play to start the calibration. Press Mill Offset to start the membrane offset calibration. Select the temliftout-15x4um.recipe. Select Mill. The script will mill two crosses. The script will find them by matching, and it will mill a third cross in the middle of the other two, based upon the found crosses. The script will then find the third cross by matching and calculate the difference with the mill position. The calibrated values are written to the registry automatically.

  For the circle offset, press Play to start the calibration. Press Circle Offset to start the circle offset calibration. The procedure is similar to the Mill Offset calibration procedure.

- 6. **LogAllDefaults.psc:** This script reads the variables in *DialogDefaults.ini* and *SystemValues.ini* and writes them to a file named *Autolog.1* in case you ever need to restore these values. Press Play to start the script.

Troubleshooting

AutoTEM™ Wizard is designed to avoid many errors that may occur during the TEM sample specification process. The FIB system and its operating software are also equipped to resolve errors that may occur during sample milling.

If you encounter an error that requires user intervention, you may be able to resolve it by following the procedures described below.

TABLE 8-21 TROUBLESHOOTING

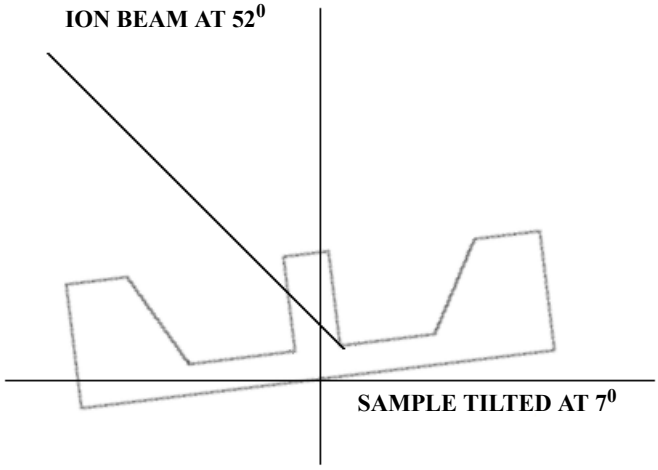
Error	Potential Cause	Possible Solutions
Match Failed dialog box appears (image recognition failure).	Stage height is incorrectly set.	Set the stage at eucentric height.
	Crosses are outside the field of view.	Move the stage or shift the beam to bring the crosses within the field of view.
	Image quality is poor.	Adjust focus, stigmation, contrast, brightness, etc. to obtain an image that is easier for the image recognition to match.
Liftout sample is hard to pluck.	Sample is still partially or completely attached.	Cut the sample free manually, rather than using image recognition to place the cuts. For manual control, set **polishstep** to 0.
		Cut the sample entirely free from above after running the script. In this case, beware of redeposition on the TEM membrane face. Make sure the sample is cut free at the bottom. Because the stage is tilted at 45° while the sample is cut free, the bottom cut must be made at such a height that the ion beam passes completely through the sample.
Sample falls into trench and is difficult to pluck.	The trench is too deep.	Mill a shallower trench.

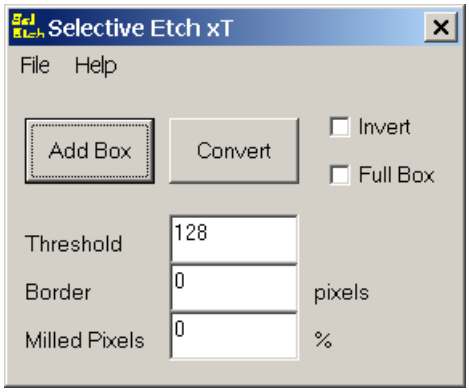
TABLE 8-21 TROUBLESHOOTING

Error	Potential Cause	Possible Solutions
Sample breaks free too soon.	The automatic cuts are too long and damage the platinum bridges attaching the sample to the walls of the trench.	Cut the sample free under manual control. To disable automatic cutting, edit the script manually and set **docutout to 0 in the recipe file**, then rerun the data file from RunScript. You can also let the system cut one side and the bottom free, then cut the last side free under manual control. See Table 3 "*Recipe File Parameters"*.
	Sample is incorrectly oriented.	Orient TEM samples along the grain axis of the crystal to prevent them from being stressed. Otherwise, they may buckle or break free.
Sample is bent or damaged.	Sample is too thin.	Increase the final sample thickness (by editing **targetthickness**) so that the script leaves a thicker sample.
		Carefully cut the final slices off the sample under manual control so that you can tell when the sample is about to bend or be damaged by the ion beam. Stop milling as soon as it appears that the sample may be bending.
	Sample is incorrectly oriented.	Orient TEM samples along the grain axis of the crystal to prevent them from being stressed. Otherwise, they may buckle or break free.

Selective Etch Software

Selective Etch for XT Software provides precise milling, etching, and deposition on samples by creating a milling pattern based on the intensity of an image. With Selective Etch, only pixels of a predetermined brightness or darkness (based on the threshold value of the grayscale) within a chosen area are scanned. And reduced scanning, for example at the edge of a metal track, is also possible by creating a border (an unscanned area around each feature).

How Selective Etch works



Selective Etch uses an image of a scanned area to develop a milling pattern conforming to specific features on a sample. Because metal layers appear much brighter than passivation in the secondary electron mode, the software can use a grayscale threshold to exclude the bright areas of metal from the pattern.

- Add Box – Select the 'Add Box' Button on the Selective Etch interface to select an area for milling.
- Convert – A bitmap of multiple pixels is generated from the selected area.
- Invert – Invert Selected area into a negative image.
- Full Box – Fill Complete Box without threshold.
- Threshold – Any area with pixel intensity higher than the grayscale threshold is excluded from the generated bitmap image.
- Border – The border option adds additional pixels for broadening.
- Milled Pixels – Percentage of pixels in viewing window.

Instruction for milling a selected area

1. Grab a Frame by Pressing the 'Snapshot' Button in the XT UI.
2. Press 'Add Box' from XT Selective Etch UI and select the milling area.
3. Set a suitable grayscale value in the 'threshold' edit box.
4. Press 'Convert' to create a new bitmap.
5. Repeat 3 and 4 until an optimum is reached

After Conversion the selected area is saved as a bitmap file that can be found in the following directory as: C:\Program Files\FEI\Appexe\tempimage.bmp.

The milling properties of the bitmap can be edited in the patterning page control of the UI. Examples of editable properties are: Application File, Dwell time, Scantype, Refreshtime…

Scantype defines the strategy that is being used for scanning. This is either raster or serpentine scan.

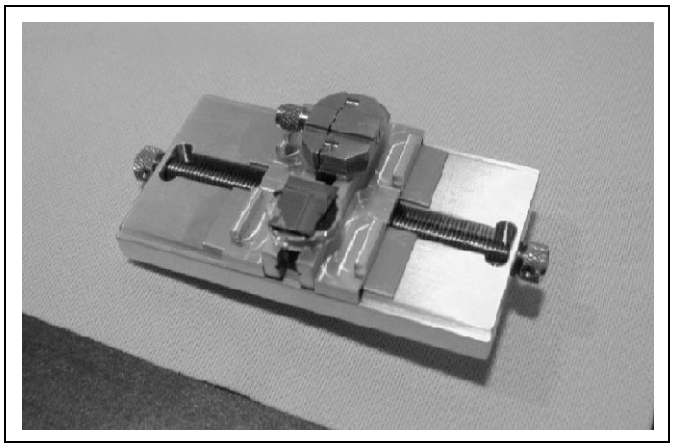
Refresh time is defined as the minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed. The ion beam is blanked while waiting.

Sample Holders

Sample Vise

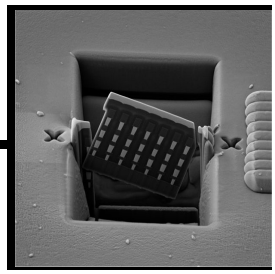
On a Nova NanoLab use the Sample Vise, to hold the sample mount and dual TEM grid holder simultaneously.

FIGURE 9 PGA VISE



The Vise fits directly on the rotation table of the NanoLab stage.

9 ALIGNMENTS



Overview

This Chapter describes procedures for aligning the Electron and Ion columns for Supervisors, FEI trained Supervisors and Users. The alignment functions allocated are displayed in the Alignment Page. Only FEI Service engineers with password access can enter the Service Alignments page. When all necessary alignments are performed properly, the image will stay in focus, its rotation will be corrected, and it will not show a substantial image displacement when kV and, or beam current are changed. Further more the Ion beam and Electron beam should be in coincidence and report the same sample location accurate for milling / imaging purposes.

NOTE: It is assumed that the FEI-trained Service Engineer's mechanical alignment of the column is correct before the Supervisor can properly perform the software User alignment.

CAUTION! Read this entire chapter before attempting any alignment corrections.

!

General description and structure

Go to the Alignment pages. Open the list box by clicking on the down arrow, and then choose the Alignment needed. Always follow the instructions given in the Instructions module. Click on the Start button and proceed with following pages. During alignment procedures it is allowed to change magnification, scanning speed, to use reduced area and to optimize image brightness and contrast. If it is not forbidden for a particular alignment, it is also possible to stigmate and to focus the image. However, it is not allowed to manually change Mode, Spotsize, and High Voltage or to use the beam shift during an alignment procedure.

Common behaviour buttons

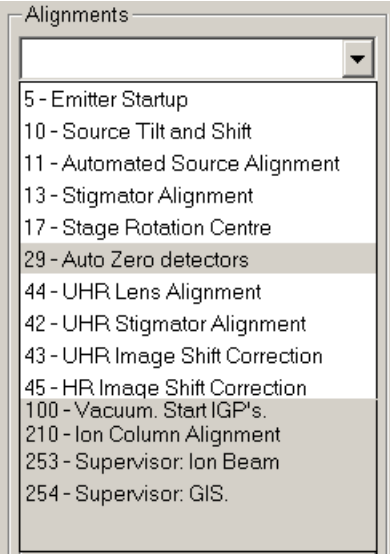
The following buttons and behaviors are common for all alignment pages. When available, they have the following effects:

- The **Next** button moves the user to the following page after all the necessary settings have been selected.
- The **Previous** button moves the user to the previous page should a previous setting need to be changed.
- The **Finish** button completes the procedure and saves the new settings.
- The **Save** button saves the actual settings at that point.
- The **Cancel** button (at any time) returns to the start without having changed the original settings or the settings saved the last time by

clicking the Save button.

CAUTION! Electron column alignments should always be performed in Quad 1. In other cases it is not possible to ensure correct functionality of the Contrast, Brightness and Auto functions used in the Alignments pages.

Electron Column Alignment


Alignments
5 - Emitter Startup
10 - Source Tilt and Shift
11 - Automated Source Alignment
13 - Stigmator Alignment
17 - Stage Rotation Centre
29 - Auto Zero detectors
44 - UHR Lens Alignment
42 - UHR Stigmator Alignment
43 - UHR Image Shift Correction
45 - HR Image Shift Correction
100 - Vacuum. Start IGP's.
210 - Ion Column Alignment
253 - Supervisor: Ion Beam
254 - Supervisor: GIS.

Alignment procedures

The Alignment of the Electron column can be performed by a Supervisor using the well-defined procedures found in the Alignments Page when opened. Not all alignments in the list need to be performed at the same time therefore further explanation below characterizes the procedures for the Supervisor.When the necessary column alignments are performed properly the Electron image will stay in focus, and will not show a substantial image displacement when changing kV or spotsize.

The greyed out area in the list is not found in the software but is just to highlight the alignments with a white background described for the Electron column.

Final Lens Aperture Strip

Before any Electron column alignment should be made a Supervisor should align the Final Lens aperture strip by manual mechanical positioning. The procedure to do this can be found in this chapter before any of the software alignments are fully described.

E-Column Alignments for Supervisors

This list is in procedural order:

10 Source Tilt and Shift

44 UHR Lens Alignment

42 UHR Stigmator Alignment

43 UHR Image Shift Correction

45 HR image Shift Correction

The above alignments should be carried out in this order only, and only when necessary, for instance if the column alignment has been disturbed by an event.

10 Source Tilt and Shift should be checked on a regular basis of approximately every two weeks and if beam centers are not correct then the above alignments should be made in the respective order. Correction of only one procedure may influence others; therefore care should be taken to monitor the influence of actions made.

NOTE: Do not use Beam Shift at any time during the adjustment procedures, other than where specified, as this is set to zero value at each alignment section, and extra movement can offset the zero condition.

All movement of the specimen can be made using the stage, either mechanical or motor driven, where appropriate.

Supervisors should only use the 11 Automated Source Alignment when the full Supervisor Column Alignments has been carried out successfully.

Electron-Column Alignment Overview

Supervisors only

TABLE 9-1 E-COLUMN ALIGNMENT ALLOCATION

Procedures in order	Function
SUPERVISOR	
10 - Source Tilt and Shift	Corrects source tilt and shift for the whole range of the accelerating voltages and spotsizes.
44 - UHR Lens Alignment	Eliminates image shift when focusing in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.
42 - UHR Stigmator Alignment	Alignment Eliminates image shift during normal stigmator correction in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.
43 - UHR Image Shift Correction	Eliminates image shift during HV change in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.
45 - HR image Shift Correction	Eliminates image shift during HV change in Mode 1 for the whole range of the accelerating voltages.
11 - Automated Source Alignment	This performs certain optimizations that improve the imaging conditions of the SEM when those conditions have been lost. The optimizations are similar, but not as complete as those performed manually in Adjustment 10. Full manual alignment of the column (10, 44, 42, 43, and 45) should have been performed before alignment 11 can be used.
29 - Auto Zero detectors	This alignment has to be performed after a power disconnection of the STEM and CDEM amplifier

FEI Trained Supervisors /FEI Service

After Emergency shutdown, only a FEI trained Supervisor should start the Electron source with 5 Emitter Startup otherwise FEI Service should be informed of the condition.

TABLE 9-2 E-COLUMN ALIGNMENT ALLOCATION

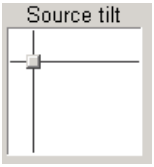
Procedures in order	Function
FEI TRAINED SUPERVISOR	or FEI SERVICE
5 - Emitter Startup	Enables electron gun switching on/off and to change gun emission mode. In the case of an emergency shut down it also makes it possible to restart the IGPs. For FEI trained Supervisor or FEI Service use only.

Users (all)

For local correction in Mode 1, 2 and 3 the following two fine controls are available to all and not subject to the restrictions above:

TABLE 9-3 E-COLUMN ALIGNMENT ALLOCATION

Procedures in order	Function
USER	
13 - Stigmator Alignment	This alignment eliminates image shift during normal stigmator correction in both Modes 1, 2 and 3.
17 - Stage Rotation Center	Corrects the center of rotation at any point on the specimen by computer correction of the X, Y offset from the stage mechanical center.



Tips for X and Y Corrective Movement

Alignments may require some corrective movements in X anY direction at the same time. This is simplified by X and Y being represented as a 2D Graphical adjuster. When the 2D box is clicked on, and the left-hand mouse button is held in, a cross-hair shows on the screen with a small 4 ended arrow cursor located in the center. By moving the mouse the cross-hairs move and therefore affect the image as required. Due to the fact that the probe rotation correction is switched off automatically in some alignment procedures the X and Y movements may not always appear to be in the same directions.

NOTE: Do not use Beam Shift at any time during the adjustment procedures, other than where specified, as this may be set to zero value at each section, and extra movement can offset the zero condition. All movement of the specimen can be made using the stage, either mechanical or motor driven, where appropriate.

How all software alignments are described

At the beginning of each alignment, with the exception of the Aperture Alignments, there are the following:

- An Outline of the Function - What it does.
- Field Functions - A description of the field functions found on the pages.
- The Procedure in Steps - A step by step procedure for correcting alignment.

NOTE: Text found in the Text areas of the alignment program may differ slightly from that found in the following written procedures. The written procedures here are not space restricted and therefore more explicit.

All software alignments have the same page form and the common functions for each alignment can be found throughout the pages. Here are the most common field functions:

TABLE 9-4 COMMON FIELD FUNCTIONS

Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
Previous	Click on Previous to go to the previous Step.
Next	Click on Next to go to the following Step.
Cancel	Click on Cancel to leave the alignment and return to original settings.
Finish	Click on Finish to save the procedure and exit

E-Column Aperture Alignment

Recommended Apertures

Aligning the E-Column aperture is a mechanical process. The apertures are in a Mo/Si strip form, so it is a case of choosing the one most applicable to your imaging needs. Table 9-2 provides guidelines for the use of aperture sizes.

TABLE 9-5 GUIDELINES FOR APERTURES SIZES AND THEIR USES

Aperture	Use
1000µm	Service Alignment (hole in frame)
100	High current applications
50 µm	X-ray mapping of low-Z elements at low kV
40 µm	General imaging or X-ray analysis
30 µm	High resolution imaging

Aperture Loading Guidelines

The aperture holder rod is heated while in operation to keep the apertures in a clean state. In addition the aperture strip is mounted within a module that can be attached to the rod by a single screw.The aperture strip and module is supplied as a complete unit for ease of mounting. The aperture strips come in two types:

- 5 hole 30, 30, 50, 30, 30 micron
- 5 hole 30, 30, 40, 50, 100 micron (factory default)

FIGURE 9-1 THE HEATED APERTURE HOLDER MODULE

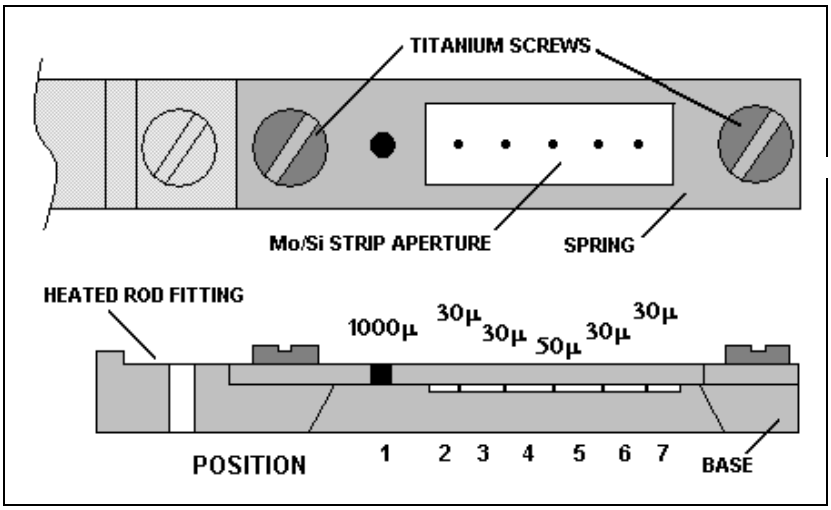
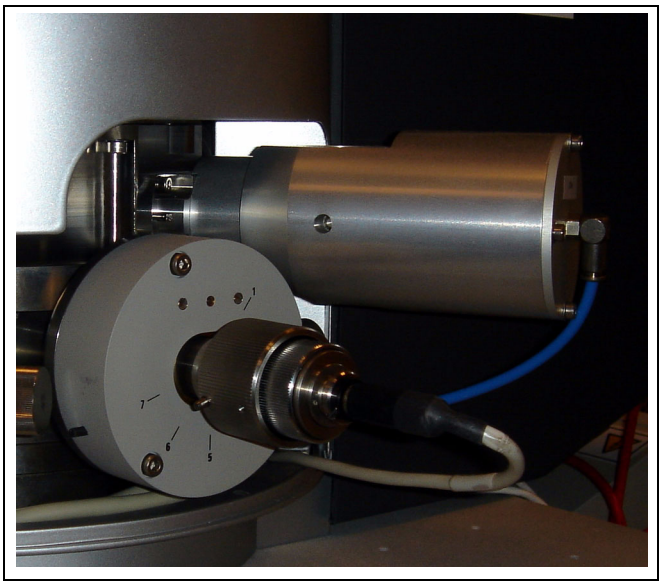


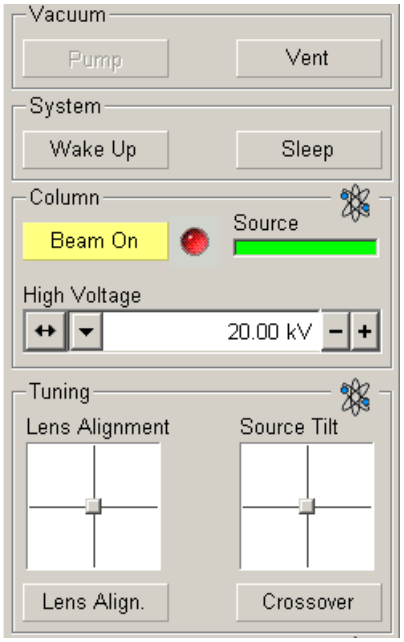
FIGURE 9-2 FINAL LENS APERTURE CONTROL



Changing Final Lens Aperture Sizes

The external control of the final lens aperture is used to change from one aperture to the next one. It has a click-stop mechanism. A left-hand turn on the large ring moves the aperture holder inward toward the larger aperture. After you change the aperture, use the inner knob and the knob on the right side to tune its position. The two knobs control the X, Y movement in a horizontal plane.

Strip Aperture Alignment Procedure



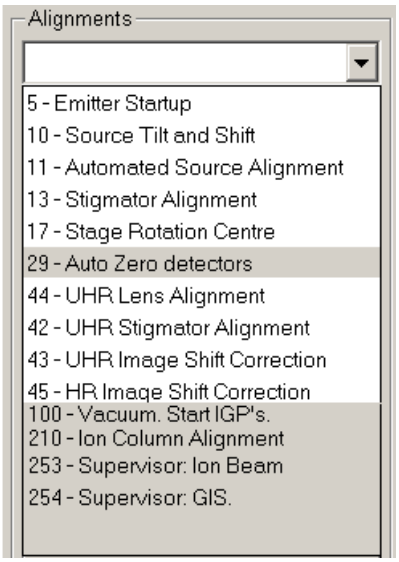
Before you align the column, be sure that the final lens aperture is correctly aligned. If the final lens aperture has to be aligned, choose the smallest for the best results. It is recommended to use 30kV and spot 3, Mode 1, with the specimen at a working distance of 5 mm, the eucentric working distance in the Strata and the Nova NanoLab.

When the aperture is well aligned, the image rotates around the center of the field of view at low magnification and does not move at high magnification during focusing. The position of the final aperture should remain constant and should not be changed further during the alignment procedures.

TABLE 9-6 ALIGNING THE FINAL LENS APERTURE

Step	Action
1	Choose Mode 1 (field-free) and set HV=30 kV, Spot= 3, FWD=5 mm. Select Zero Beam Shift from the Stage menu. Select Zero Lens Alignment by clicking the right mouse button on the 2D box center square (see Chapter 4 for more detailed description).
2	Make an image at a magnification of about 10,000X. Select a fast scan rate from the Scan Speed control and Average 4 from the Filter control on the Tool bar.
3	Move the stage to find a good area of interest, and focus as best one can.
4	Center a feature with the Get function.
5	Click on the objective Lens coil modulation (wobbler) icon in the tool bar. The scanning condition turns into the fastest scan value, the lens modulator turns on and the alignment cross appears in the center of all imaging quads. The image rotates about a point (this maybe different from the image center).
6	Adjust the position of the aperture so that the center of the rotation is under the cross.
7	Increase the magnification to 20,000X and realign. If necessary, repeat at 40,000X. At higher magnification the image may move very slightly in a certain direction. By tuning the aperture, you can minimize this movement.
8	When corrected, switch off the Lens Alignment. There should be no image shift when the focus control is used.

E-Column Alignment Procedures


Alignments
5 - Emitter Startup
10 - Source Tilt and Shift
11 - Automated Source Alignment
13 - Stigmator Alignment
17 - Stage Rotation Centre
29 - Auto Zero detectors
44 - UHR Lens Alignment
42 - UHR Stigmator Alignment
43 - UHR Image Shift Correction
45 - HR Image Shift Correction
100 - Vacuum. Start IGP's.
210 - Ion Column Alignment
253 - Supervisor: Ion Beam
254 - Supervisor: GIS.

Before you align the Electron column, be sure that the final lens aperture is correctly aligned. All alignment procedures should be operated in a fast mode of scan and with an average of 4 or 8.

Supervisor SEM Alignments

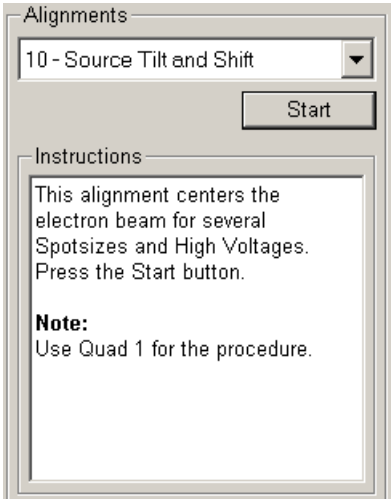
Use the **Alignment** control area to align the column and determine fine tuning for the electromagnetic system. The software stores column parameters such as Source Tilt X, Y, Source Shift X, Y, and other data that ensures minimum image shift when focusing and stigmating images. When you click on the list box arrow, various available alignments are displayed.

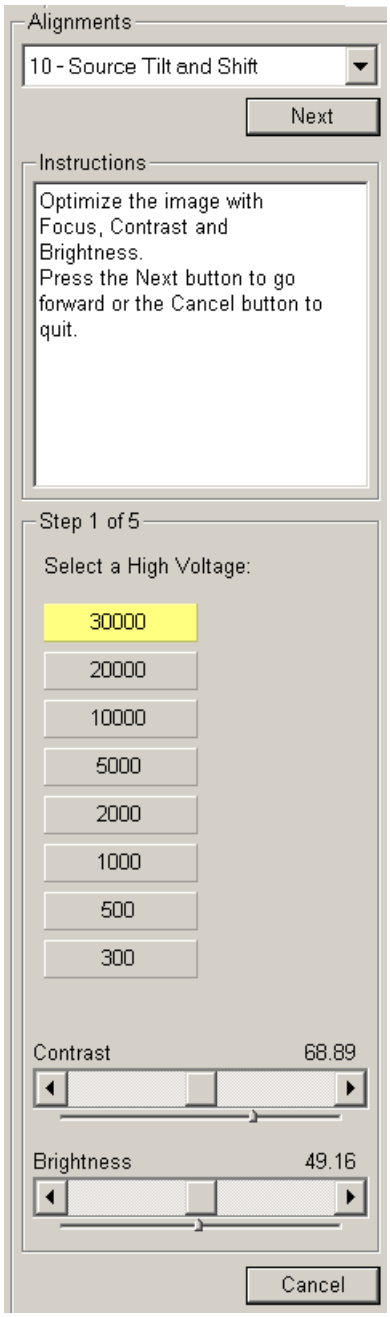
TABLE 9-7 SUPERVISOR E-COLUMN ALIGNMENTS

Adjustment	Function
10 Source Tilt and Shift	Performs main column alignment for Spot sizes for each kV step. 30 kV to 300 V in mode 1.
44 UHR Lens Align	Eliminates image shift when focusing in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.
42 UHR Stigmator	Minimizes image shift during total Stigmator correction of X and Y in the Mode 2.
43 UHR Image Shift	Aligns voltages in Mode 2 so that minimal Image Shift is seen at voltage changes.
45 HR Image Shift	Aligns voltages in Mode 1 so that minimal Image Shift is seen at voltage changes and between Mode 2 and Mode 1s.

The sequence always begins with **Instructions**, **No Step** and the **Start** button. Some of the alignments have numerous steps in the procedure, many are repetitive in content, only parameters such as kV or spotsize may have changed.

10 - Source Tilt and Shift


Alignments
10 - Source Tilt and Shift
Start
Instructions
This alignment centers the electron beam for several Spotsizes and High Voltages. Press the Start button.
Note:
Use Quad 1 for the procedure.



Alignment Function

This procedure adjusts the electron source for the whole range of voltages and spotsizes. It is possible to complete it only for the voltages which are going to be used but to correct all it is necessary to complete the procedure for all values. Before starting this alignment, the Final Lens Strip Aperture Alignment has to be done.

When each procedure ends, save the adjustments and the alignment data will be stored in the computer. When the column is correctly aligned, the image stays in focus, and does not show substantial image displacement when changing kV or spot size.

10 - Source Tilt and Shift Procedure

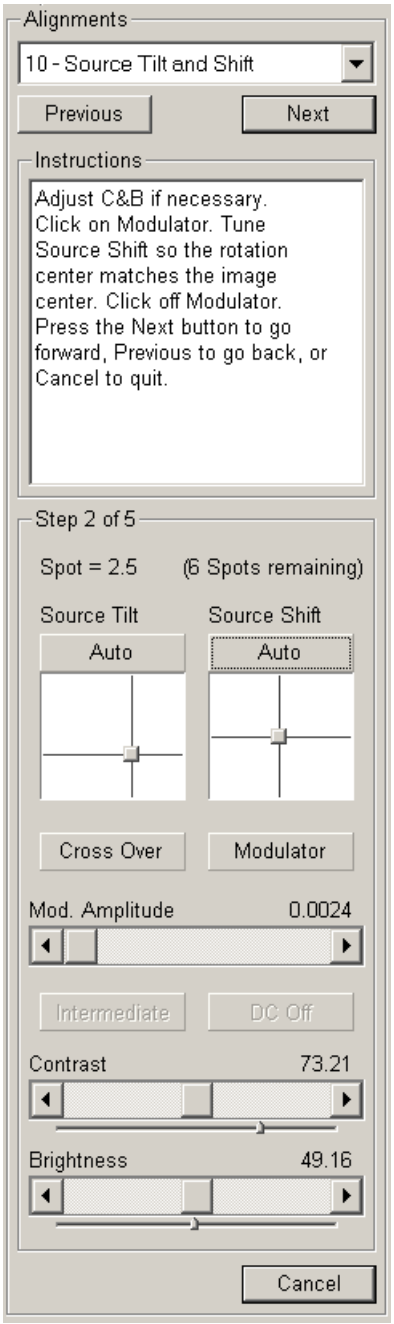
The **10 Source Tilt and Shift** alignment procedure starts here:

TABLE 9-8 10 NO STEP

Order	Action
1	Mode 1 Specimen: Tin Balls. (any suitable sample). Set FWD = 5mm Steps: 5
2	Press the Start button.

TABLE 9-9 10 STEP 1 OF 5

Order	Action
3	Select a High Voltage. Start with 30kV and work down to 300V. A green cross appears at the screen center.
4	Optimize the image with Focus, Contrast and Brightness.



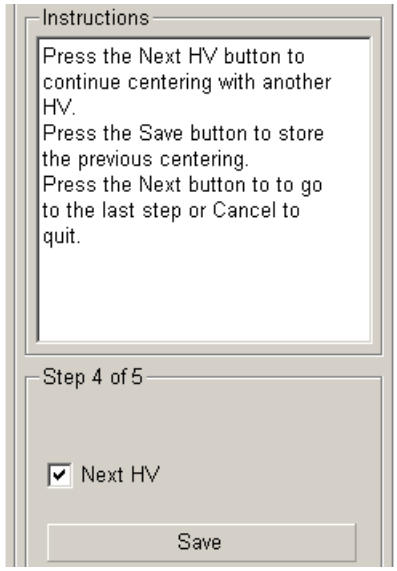

Instructions
Press the Next HV button to continue centering with another HV.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.
Step 4 of 5
Next HV
Save

TABLE 9-10 10 STEPS 2 TO 5

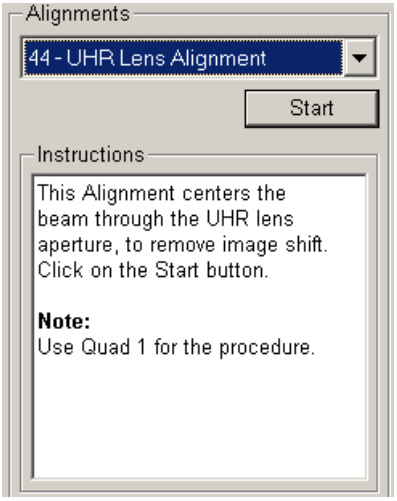
Order	Action
5	Adjust Source Tilt. Click on the Cross Over button and with the use of the 2D box set the centre of the image under the Green Cross, which indicate the holy point. Besides, for Spots 5 and higher it is recommended to switch off the Cross over mode and fine-tune for the maximum brightness.
6	Adjust Source Shift. Click on Modulator button and with the use of 2D box set the centre of the image rotation under the Center Cross. If the system is correctly aligned, the rotation center is in the center of the screen. The spot sizes will be selected progressively by clicking on the Next button
7	Repeat the Source Tilt and Shift procedure for all 7 spotsizes through Steps 2 and 3. Click on the Next button.
8	At Step 4 check the Next HV box before clicking the Save button to save the adjustments.
9	Click on the Next button to return to Step 1 to select the next HV. Repeat the procedure order from 3 to 9.
10	At the saving of the last HV spot series, do not check the Next HV box. Press the Next button. Step 5 opens and the Finish button appears. Press Finish at Step 5 to Save and exit.

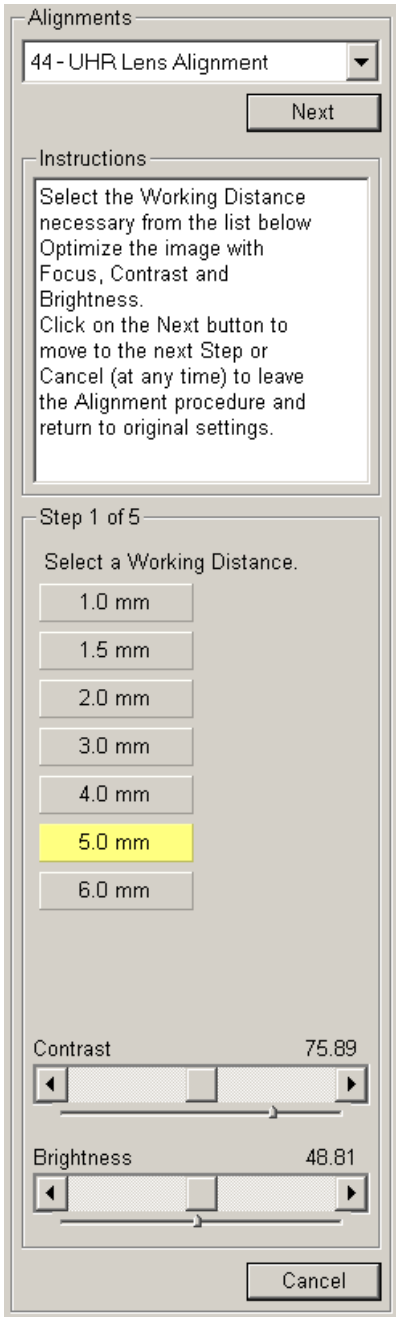
Auto Buttons

In some of the pages will be found Auto Buttons that achieve a similar result to the above described adjustments. It is possible to just click the Auto button. This function utilizes Image Recognition software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, lower magnification) or use the normal manual procedure.

NOTE: For large spots and low voltages Source Tilt and Source Shift adjustments influence each other. Therefore adjustments should be repeated several times to achieve optimal result.

44 - UHR Lens Alignment


Alignments
44 - UHR Lens Alignment
Start
Instructions
This Alignment centers the beam through the UHR lens aperture, to remove image shift. Click on the Start button.
Note:
Use Quad 1 for the procedure.



Alignment Function

This procedure aligns the beam through the UHR Lens for the whole range of voltages and working distances in Mode 2 (immersion mode). It is possible to complete it only for the voltages and working distances which are going to be used but for general adjustment it is necessary to finish it for all values. Working distances select the voltage values automatically. Before starting this alignment, alignment 10 - Source Tilt and Shift has to be completed.

44 UHR Lens Alignment Procedure

The **44 UHR Lens Alignment** procedure starts here:

TABLE 9-11 44 NO STEP

Order	Action
1	Mode 2 Specimen: Tin Balls. (any suitable sample) Steps: 5
2	Press the Start button.

TABLE 9-12 44 STEP 1 OF 5

Order	Action
3	Select a Working Distance (5 mm for Eucentric jobs)
4	Optimize the image with Focus, Contrast and Brightness.
5	Click on the Next button.

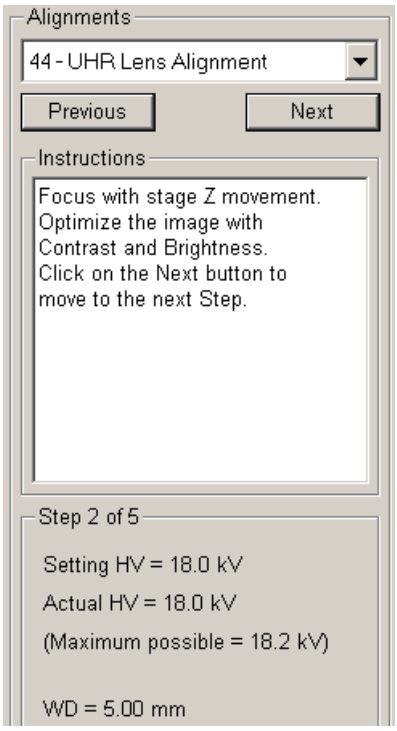


TABLE 9-13 44 STEP 2 OF 5

Order	Action
6	For the chosen WD a start HV will be displayed.
7	Focus with the Z Stage mouse movement. Click on the 4th Quad with the optical image of the stage. With the mouse wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. These movements are represented by up/down arrows. Use this to focus the object by observing the response in the 1st Quad.
8	Optimize the image for Contrast and Brightness. Press Shift F5 to display the center cross.
9	Click on the Next button.

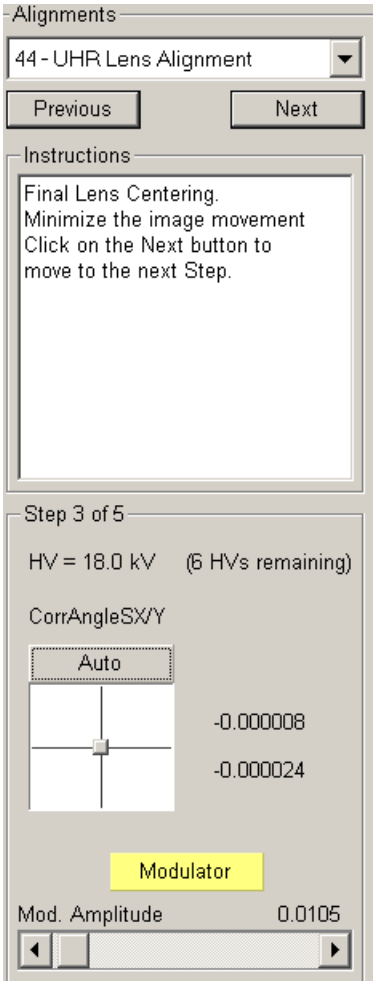


TABLE 9-14 44 STEP 3 OF 5

Order	Action
10	Click on the Modulator button and with the use of the 2D box to eliminate shift in the image. With the Mod. Amplitude slider one can set the modulating depth.
11	Press the Next button to move to the next HV. Repeat for all offered voltages then click on the Next button.

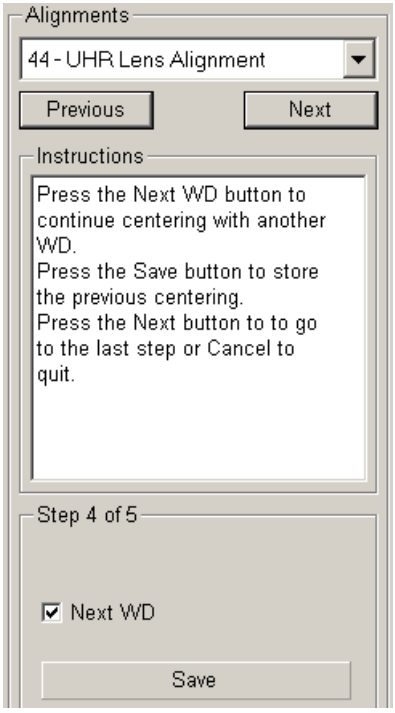

Alignments
44 - UHR Lens Alignment
Previous
Next
Instructions
Press the Next WD button to continue centering with another WD.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.
Step 4 of 5
Next WD
Save

TABLE 9-15 44 STEP 4 OF 5

Order	Action
12	At Step 4 a check box for next WD will appear with the Save button. If you are going to adjust the next WD sequence then check the Next WD check box before clicking the Save button.
13	Click on the Next button to return to Step 1 to select the next WD.
14	Repeat the procedure from Order No. 3.

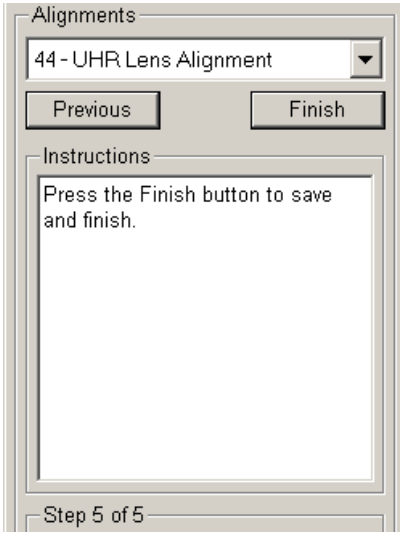


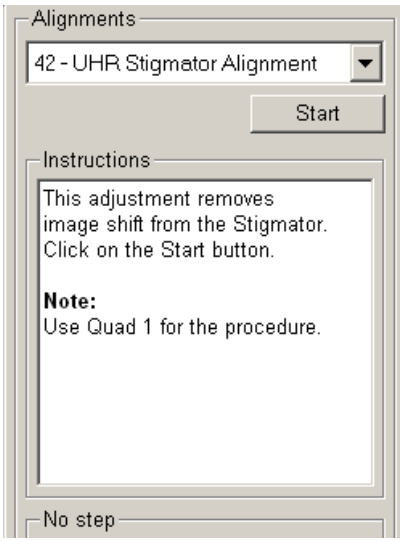
TABLE 9-16 44 STEP 5 OF 5

Order	Action
15	At the saving of the last WD / HV series, do not check the Next WD box. Press the Next button. Step 5 opens and the Finish button appears. Press Finish at Step 5 to Save and exit.

Auto Buttons

In some of the pages will be found Auto Buttons that achieve a similar result to the above described adjustments. It is possible to just click the Auto button. This function utilizes Image Recognition software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, lower magnification) or use the normal manual procedure.

42 - UHR Stigmator Alignment



Alignment Function

This procedure eliminates the image shift when stigmating in the whole range of voltages and working distances in Mode 2 (immersion mode). It is possible to complete it only for the voltages and working distances which are going to be used but for complete adjustment it is necessary to complete all values. Before starting this alignment it is necessary to complete alignments 10 - Source Tilt and Shift and 44 - UHR Lens Alignment. Do Not change the aperture condition.

42 UHR Stigmator Alignment Procedure

The **42 UHR Stigmator Alignment** procedure starts here:

TABLE 9-17 42 NO STEP

Order	Action
1	Mode 2 Specimen: Tin Balls. (any suitable sample) Steps: 6
2	Press the Start button.

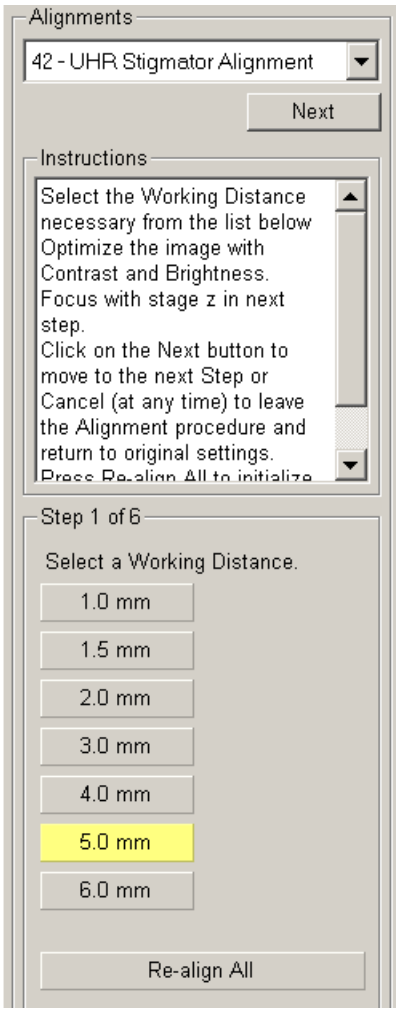

Alignments
42 - UHR Stigmator Alignment
Next
Instructions
Select the Working Distance necessary from the list below Optimize the image with Contrast and Brightness. Focus with stage z in next step.
Click on the Next button to move to the next Step or Cancel (at any time) to leave the Alignment procedure and return to original settings.
Step 1 of 6
Select a Working Distance.
1.0 mm
1.5 mm
2.0 mm
3.0 mm
4.0 mm
5.0 mm
6.0 mm
Re-align All

TABLE 9-18 42 STEP 1 OF 6

Order	Action
3	Select a Working Distance (5 mm for Eucentric jobs). If you want to keep values from Step 1of the alignment as the starting ones for all the next steps, click Re-align all button.
4	Optimize the image with Contrast and Brightness.
5	Click on the Next button.

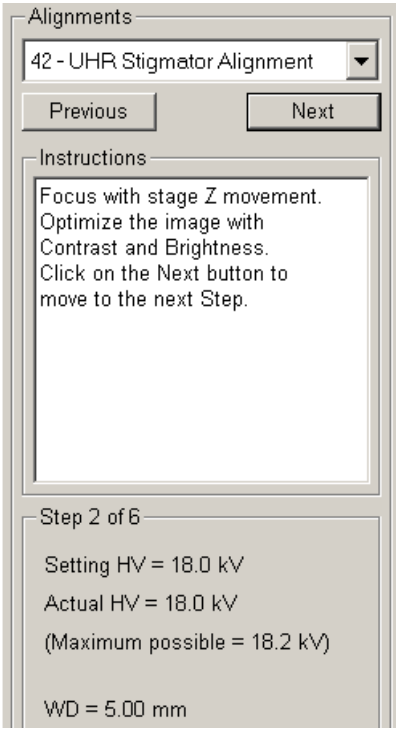


TABLE 9-19 42 STEP 2 OF 6

Order	Action
6	For the chosen WD a start HV will be displayed.
7	Focus with the Z Stage mouse movement. Click on the 4th Quad with the optical image of the stage. With the mouse wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. These movements are represented by up/down arrows. Use this to focus the object by observing the response in the 1st Quad.
8	Optimize the image for Contrast and Brightness. Press Shift F5 to display the center cross.
9	Click on the Next button.

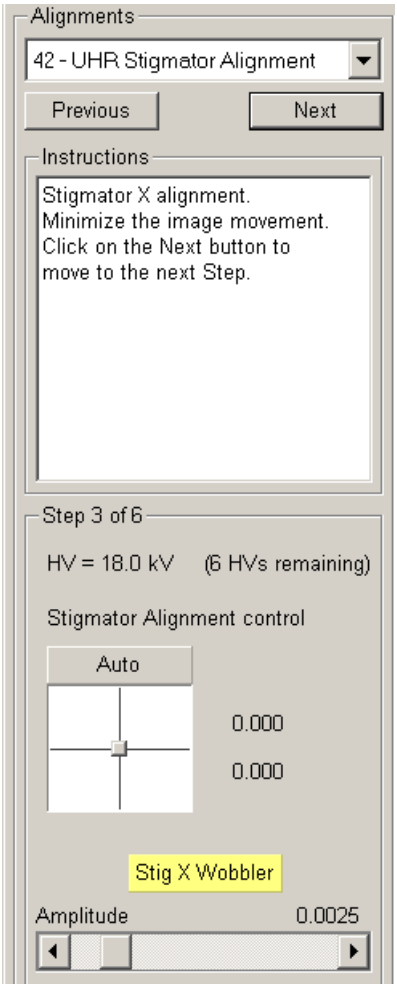


TABLE 9-20 42 STEPS 3 and 4 OF 6

Order	Action
10	Click on the Stig X / Y Wobbler and by using the 2D box labelled Stigmator Alignment control, eliminate the image shift progressively for all offered voltages. Press the Next button to move from Stig X Wobbler to the Stig Y Wobbler.
11	Click on the Next button to move to the next voltage and repeat the alignment of the Stig X/Y Wobblers.

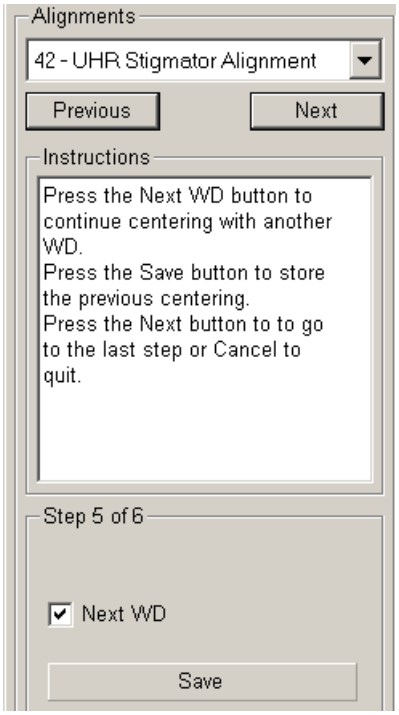

Alignments
42 - UHR Stigmator Alignment
Previous
Next
Instructions
Press the Next WD button to continue centering with another WD.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.
Step 5 of 6
Next WD
Save

TABLE 9-21 42 STEP 5 OF 6

Order	Action
12	At Step 5 a check box for next WD will appear with the Save button. If you are going to adjust the next WD sequence then check the Next WD check box before clicking the Save button.
13	Click on the Next button to return to Step 1 to select the next WD.
14	Repeat the procedure from Order No. 3.

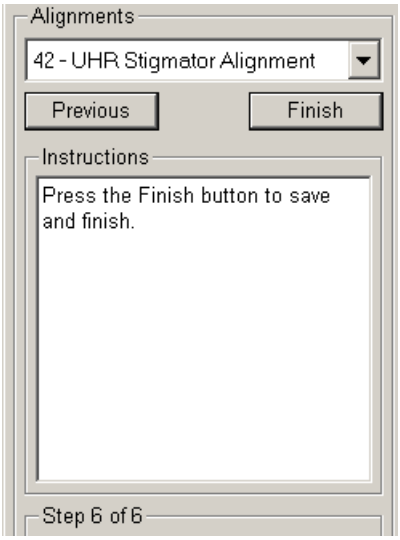


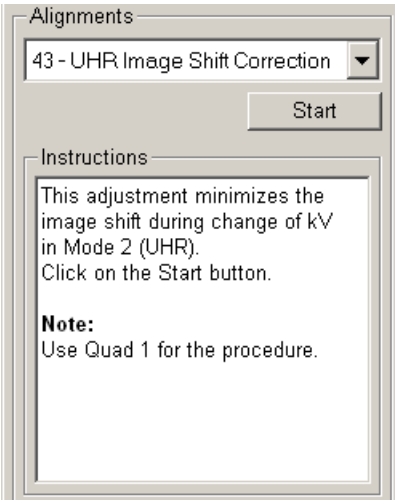
TABLE 9-22 42 STEP 6 OF 6

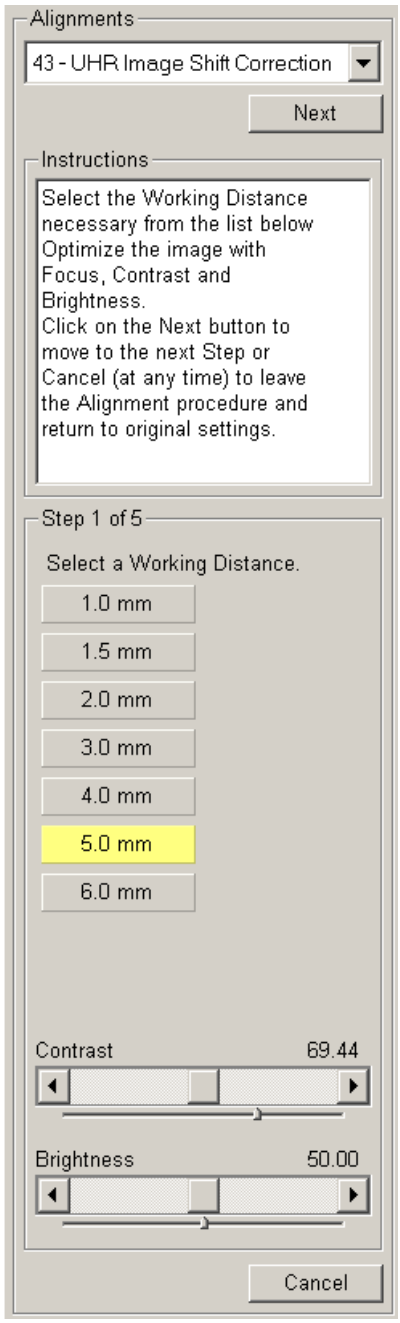
Order	Action
15	At the saving of the last WD / HV series, do not check the Next WD box. Press the Next button. Step 6 opens and the Finish button appears. Press Finish at Step 6 to Save and exit.

Auto Buttons

In some of the pages will be found Auto Buttons that achieve a similar result to the above described adjustments. It is possible to just click the Auto button. This function utilizes Image Recognition software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, lower magnification) or use the normal manual procedure.

43 - UHR Image Shift Correction


Alignments
43 - UHR Image Shift Correction
Start
Instructions
This adjustment minimizes the image shift during change of kV in Mode 2 (UHR).
Click on the Start button.
Note:
Use Quad 1 for the procedure.



Alignment Function

This procedure eliminates the image shift when changing HV in the whole range of voltages and working distances in Mode 2 (immersion mode). It is possible to complete it only for the voltages and working distances which are going to be used but for complete adjustment it is necessary to complete it for all values. Before starting this alignment it is necessary to complete alignments 10 - Source Tilt and Shift, 44 - UHR Lens Alignment and 42 - UHR Stigmator Alignment. Do Not change the aperture condition.

43 UHR Image Shift Correction Procedure

The **43 UHR Image Shift Correction** procedure starts here:

TABLE 9-23 43 NO STEP

Order	Action
1	Mode 2 Specimen: Tin Balls. (any suitable sample) Steps: 5
2	Press the Start button.

TABLE 9-24 43 STEP 1 OF 5

Order	Action
3	Select a Working Distance (5 mm for Eucentric jobs).
4	Optimize the image with Contrast and Brightness.
5	Click on the Next button.

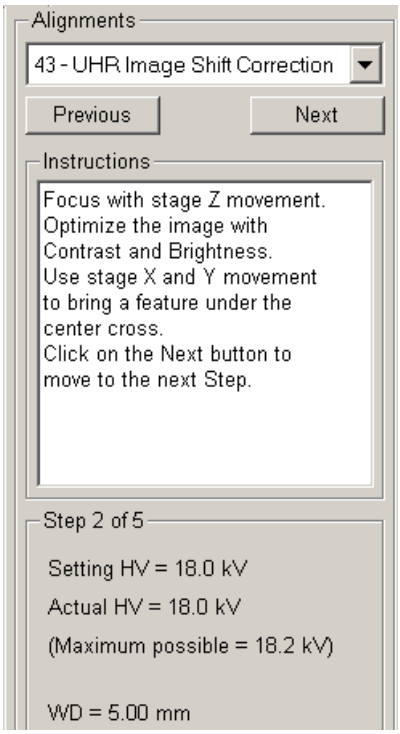


TABLE 9-25 43 STEP 2 OF 5

Order	Action
6	Focus with the Z Stage mouse movement. Click on the 4th Quad with the optical image of the stage. With the mouse wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. These movements are represented by up/down arrows. Use this to focus the object.
7	Optimize the image with Contrast and Brightness.
8	Use X, Y Stage movement to bring an object under the center cross.
9	Click on the Next button.

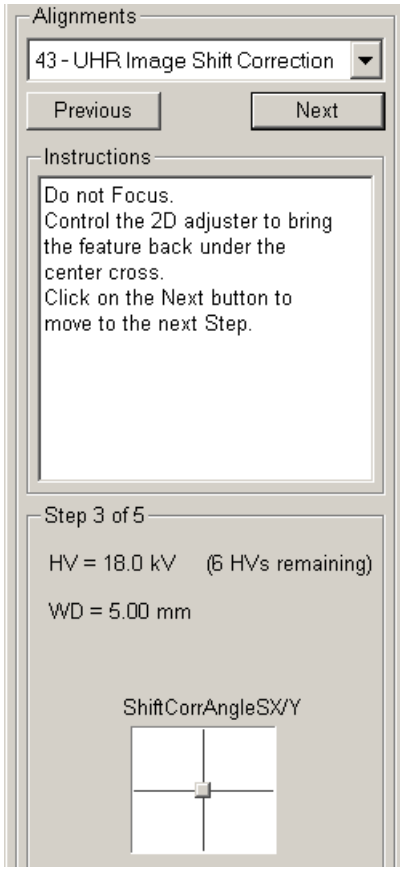


TABLE 9-26 43 STEP 3 TO 5

Order	Action
10	Do not focus.
11	By using the 2D box labelled ShiftCorrAngleSX/Y, bring the image feature back under the screen center cross.
12	Click on the Next button.
13	Repeat the procedure as for all offered voltages.
14	If you are going to adjust the next WD after finishing all of the steps for the selected WD, check the Next WD check button before clicking the Next button.

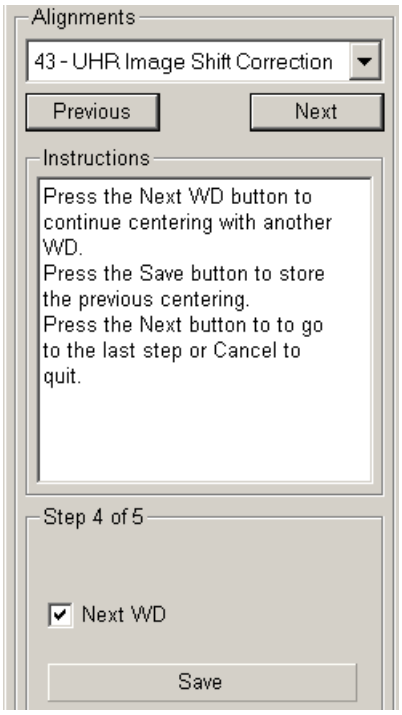

Alignments
43 - UHR Image Shift Correction
Previous
Next
Instructions
Press the Next WD button to continue centering with another WD.
Press the Save button to store the previous centering.
Press the Next button to to go to the last step or Cancel to quit.
Step 4 of 5
Next WD
Save

TABLE 9-27 43 STEP 4 OF 5

Order	Action
15	At Step 4 a check box for next WD will appear with the Save button. If you are going to adjust the next WD sequence then check the Next WD check box before clicking the Save button.
16	Click on the Next button to return to Step 1 to select the next WD.
17	Repeat the procedure from Order No. 3.

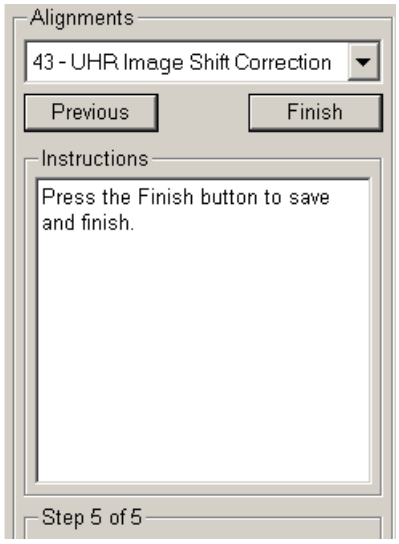
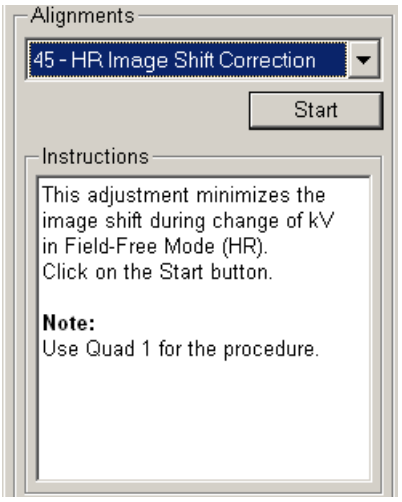
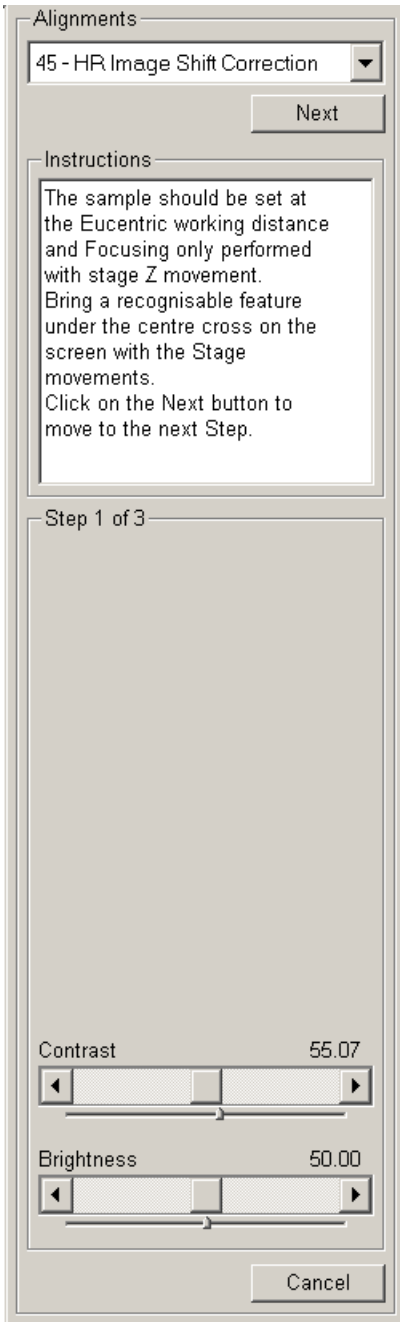


TABLE 9-28 43 STEP 5 OF 5

Order	Action
18	At the saving of the last ShiftCorrAngleSX/Y, do not check the Next WD box. Press the Next button. Step 5 opens and the Finish button appears. Press Finish at Step 5 to Save and exit.

45 - HR Image Shift Correction


Alignments
45 - HR Image Shift Correction
Start
Instructions
This adjustment minimizes the image shift during change of kV in Field-Free Mode (HR).
Click on the Start button.
Note:
Use Quad 1 for the procedure.


Alignments
45 - HR Image Shift Correction
Next
Instructions
The sample should be set at the Eucentric working distance and Focusing only performed with stage Z movement.
Bring a recognisable feature under the centre cross on the screen with the Stage movements.
Click on the Next button to move to the next Step.
Step 1 of 3
Contrast
55.07
Brightness
50.00
Cancel

Alignment Function

This alignment allows one to eliminate the image shift during changes of HV in Mode 1(Field Free mode). Before starting this alignment it is necessary to complete alignments 10 - Source Tilt and Shift, 44 - UHR Lens Alignment, 42 - UHR Stigmator Alignment and UHR Image Shift Correction. Do Not change the aperture condition.

45 HR Image Shift Correction

The **45 HR Image Shift Correction** procedure starts here:

TABLE 9-29 45 NO STEP

Order	Action
1	Mode 2 WD = 5.0mm (The working distance should be set at the Eucentric position). Specimen: Tin Balls. (any suitable sample) Steps: 3
2	Press the Start button.

TABLE 9-30 45 STEP 1 OF 3

Order	Action
1	Select Mode 1.
2	Focus with the Z Stage mouse movement. Click on the 4th Quad with the optical image of the stage. With the mouse wheel pressed, moving the mouse up will move the Z up and moving the mouse down will move the Z down. These movements are represented by up/ down arrows. Use this to focus the object.
3	Bring a recognisable image feature under the screen Centre Cross with the use of stage movement (do not use the beam shift!).
4	Click on the Next button.
5	Select mode 1. The HT is auto-selected starting at 30kV indicated by First HT in the Instructions.
6	Correct Contrast and Brightness if necessary

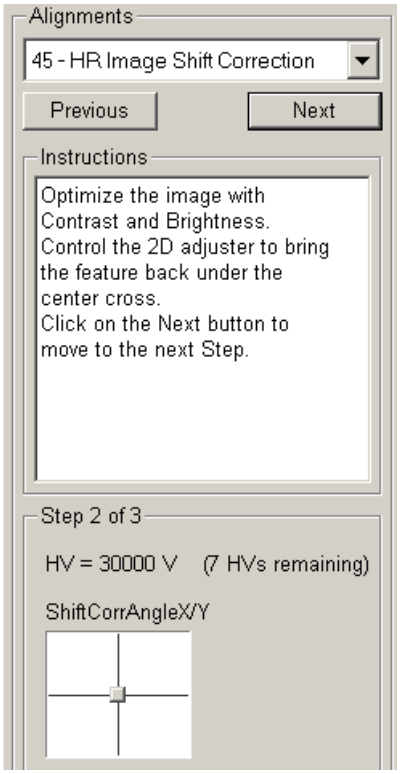

Alignments
45 - HR Image Shift Correction
Previous
Next
Instructions
Optimize the image with Contrast and Brightness.
Control the 2D adjuster to bring the feature back under the center cross.
Click on the Next button to move to the next Step.
Step 2 of 3
HV = 30000 V (7 HVs remaining)
ShiftCorrAngleX/Y

TABLE 9-30 45 STEP 1 OF 3

Order	Action
7	Tune Shift CorrAngleX/Y to bring the object back to the original position under the annotated shape and reduce the shift in the image.
8	Click on the Next button.

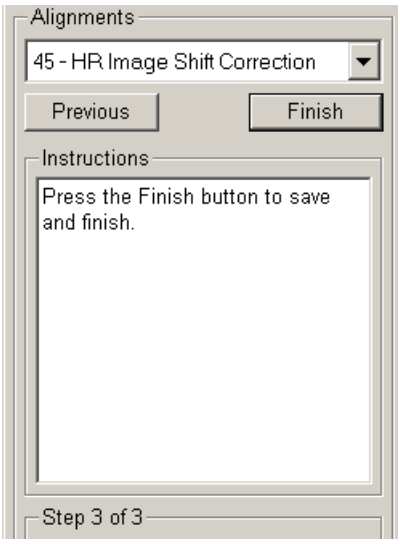
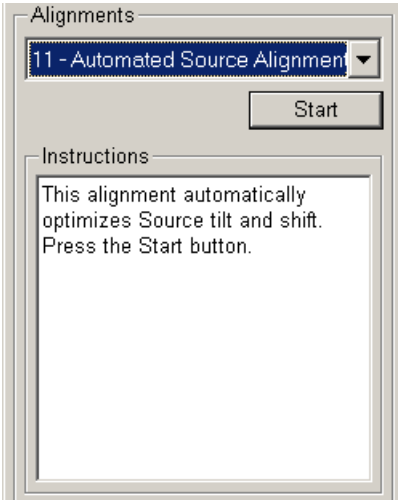
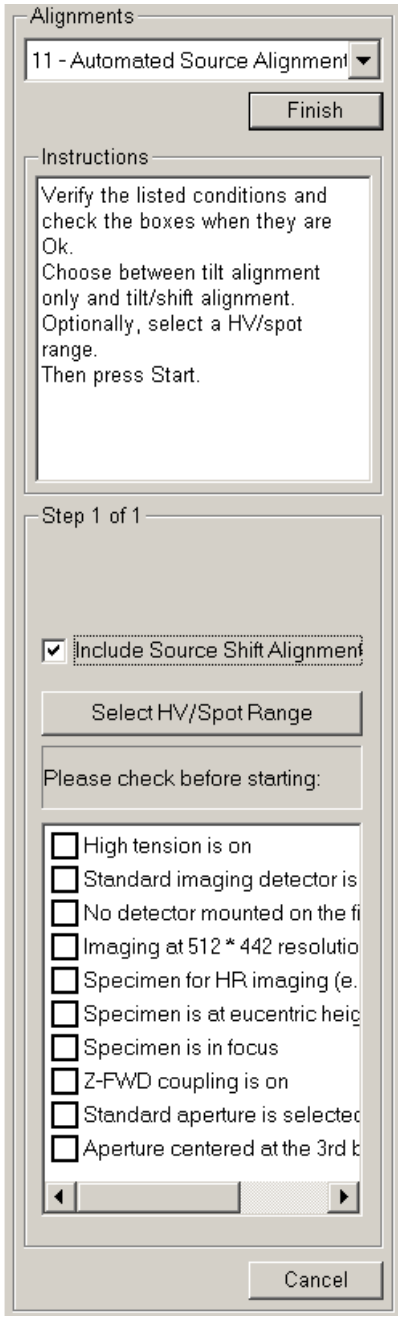


TABLE 9-31 45 STEPS 2 TO 3

Order	Action
1	Optimize the image with Contrast and Brightness.
2	By using the 2D box labelled ShiftCorrAngleSX/Y, bring the image feature back under the screen center cross.
3	Click on the Next button.
4	Repeat the procedure as for all offered voltages.
5	Press the Next button. Step 3 opens and the Finish button appears. Press Finish at Step 3 to Save and exit.

11 - Automated Source Alignment




Alignments
11 - Automated Source Alignment
Finish
Instructions
Verify the listed conditions and check the boxes when they are Ok.
Choose between tilt alignment only and tilt/shift alignment.
Optionally, select a HV/spot range.
Then press Start.
Step 1 of 1
Include Source Shift Alignment
Select HV/Spot Range
Please check before starting:
High tension is on
Standard imaging detector is
No detector mounted on the fi
Imaging at 512 * 442 resolutio
Specimen for HR imaging (e.
Specimen is at eucentric heig
Specimen is in focus
Z-FWD coupling is on
Standard aperture is selected
Aperture centered at the 3rd k
Cancel

Alignment Function

The Automatic Source Alignment can be started from the Alignment Page. Your FEI contact person or service engineer will give you advice about when it is appropriate to run this alignment.

The Automated Source Alignment will perform certain optimizations that improve the imaging conditions of the SEM. These optimizations are analogous to those performed manually in Adjustment 10.

First you should now indicate whether you want to have only Source Tilt alignment done (as shown above) or you want to have also the Source Shift Alignment done. For the latter, check the appropriate check box. The list of conditions to check changes in that case.

Notes about the conditions:

- Apart from videoscope, histogram and the cross shown in cross-over mode, also any graphics created in the 'frame store' by the graphics editor in the ImageManipulation control page must be erased, otherwise the alignment will not be able to work correctly.
- If possible, select the SED or TLD detector.
- The shift alignment requires a specimen that shows several well-distinguishable, irregular features in the image at a magnification of about 10000x and with slight defocus. One can use a tin ball sample provided that there are no large balls near the selected location. Often ideal locations are found in areas where only a few, small tin balls are visible. Gold on carbon samples with not too fine gold particles are also suitable.

Before or after checking the conditions, you can inspect and change the spot and High Voltage subranges over which the alignment will be performed.

Note that the upper and lower HV ranges overlap. This ensures good performance between 5 and 10 kV.

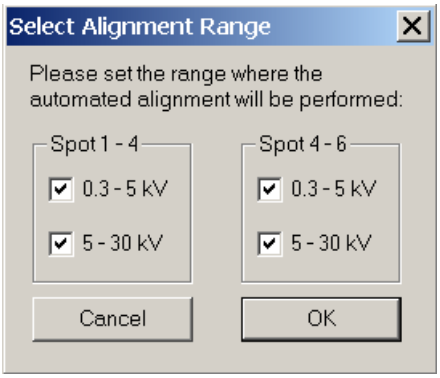
In mode 2, the alignment can not be done at 30 kv, and on some systems also not at 20 kV. This will be checked by the alignment when it starts and you will be warned if the selections conflict.

In mode 2 the alignment performance below 10 kV is however considerably better than in mode 1.

You may now click on Start. The automatic alignment still checks a number of essential settings:

- HV is on
- Cross-over mode is off
- in the case when Shift alignment is selected: Z-FWD coupling is active

If such a condition is not fulfilled, a dialog comes up that will ask you to take care of this, e.g. Clicking on 'Yes' will continue the procedure; 'No' will stop the alignment.


Select Alignment Range
Please set the range where the automated alignment will be performed:
Spot 1 - 4
0.3 - 5 kV
5 - 30 kV
Spot 4 - 6
0.3 - 5 kV
5 - 30 kV
Cancel
OK

These dialogs have a time-out of 10 minutes; after that time, the alignment will automatically abort itself without making any changes to the saved data.

When the alignment is running, the flashing text shows 'Aligning'.

Run times are in the order of 15 minutes (all subranges, tilt alignment only) to 1:15 hr (all subranges, shift alignment included).

You can interrupt the alignment by clicking on Stop. This button will start flashing until the alignment procedure has finished restoring previous instrument conditions.

When the alignment is finished, or when it has been interrupted, the following dialog comes up:

If you answer 'No' here, the source alignment data in the instrument will be reset to those that were in effect before you started the alignment. 'Yes' makes the results of the already performed alignments effective and saves them 'to machine data'.

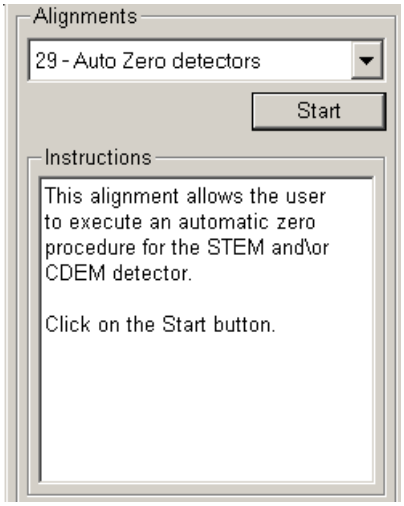
Note that the results are always made effective and saved in the end if the alignment is not interrupted.

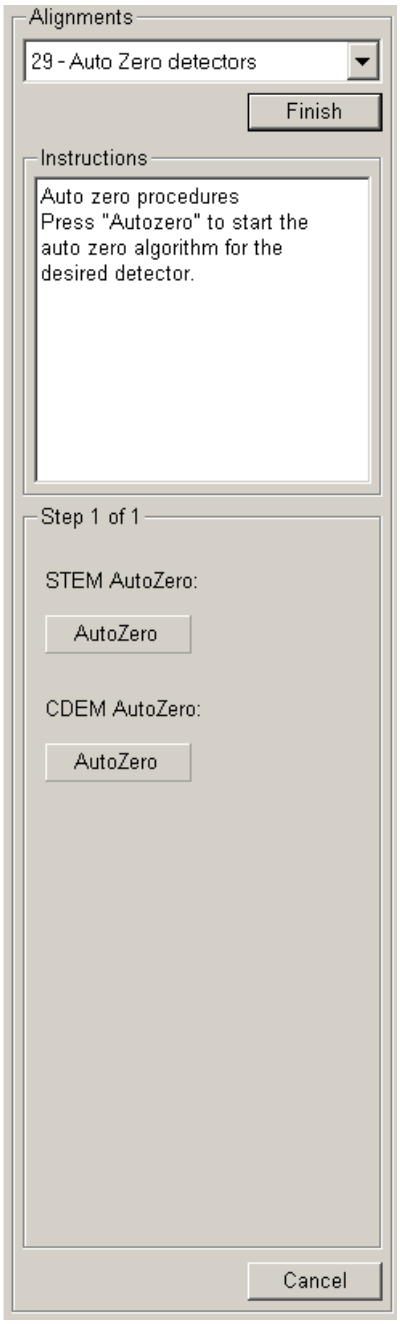
It is recommended not to close the Automatic Alignment window when an alignment is still running. This may result in an undefined state of the instrument control software.

When the alignment is stopped, you can restart another alignment run or close the window..

NOTE: If the Automatic Alignment is interrupted, the High Tension will be switched off after the alignment is finished.If the Automatic Alignment has been stopped earlier, the beam is blanked but the HT remains on.

29 - Auto Zero detector


Alignments
29 - Auto Zero detectors
Start
Instructions
This alignment allows the user to execute an automatic zero procedure for the STEM and\or CDEM detector.
Click on the Start button.



Alignment Function

The Auto Zero STEM and CDEM Detector alignment will execute an automatic zero procedure for the those detector. This alignment has to be performed after a power disconnection of the STEM or CDEM amplifier. In practice this will happen when the microscope is set to standby or turned off completely.

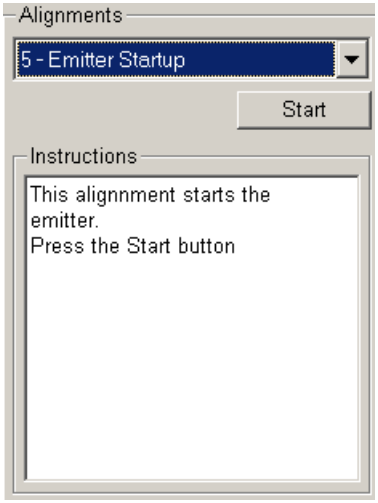
29 Auto Zero detectors procedure

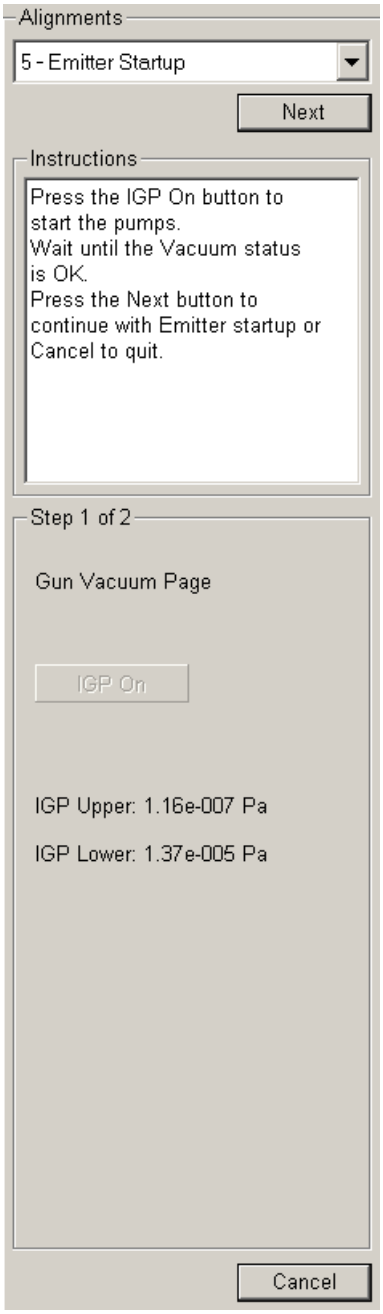
The **29 Auto Zero detectors** procedure starts here:

TABLE 9-32 29 NO STEP TO 1 OF 1

Order	Action
1	Press the Start button
2	Click on the detector AutoZero button for the appropriate detector. Repeat for each detector.
3	Click on the Finish button.

5 - Emitter Startup




Alignments
5 - Emitter Startup
Next
Instructions
Press the IGP On button to start the pumps.
Wait until the Vacuum status is OK.
Press the Next button to continue with Emitter startup or Cancel to quit.
Step 1 of 2
Gun Vacuum Page
IGP On
IGP Upper: 1.16e-007 Pa
IGP Lower: 1.37e-005 Pa
Cancel

FEI Trained Supervisor SEM Alignments

This alignment should only be operated by a FEI trained Supervisor.

Alignment 5 Emitter Startup allows the Electron Source to be switched On or Off. In the case of restarting the Electron Source after an emergency shutdown this function first provides starting of the IGP (Ion Getter Pump) to pump the Electron Source vacuum, if necessary.

5 Emitter Startup Procedure

The **5 Emitter Startup** procedure starts here:

TABLE 9-33 5 NO STEP

Order	Action
1	Press the Start button.

TABLE 9-34 5 STEP 1 OF 2

Order	Action
2	If the IGP On button is not accessible, click on the Next button. If it is accessible, click on it to automatically startup the ion pump. This procedure will take a few minutes. If the ion pump start is not successful, call FEI Service.
3	If the vacuum in the IGP is OK, click on the Next button.

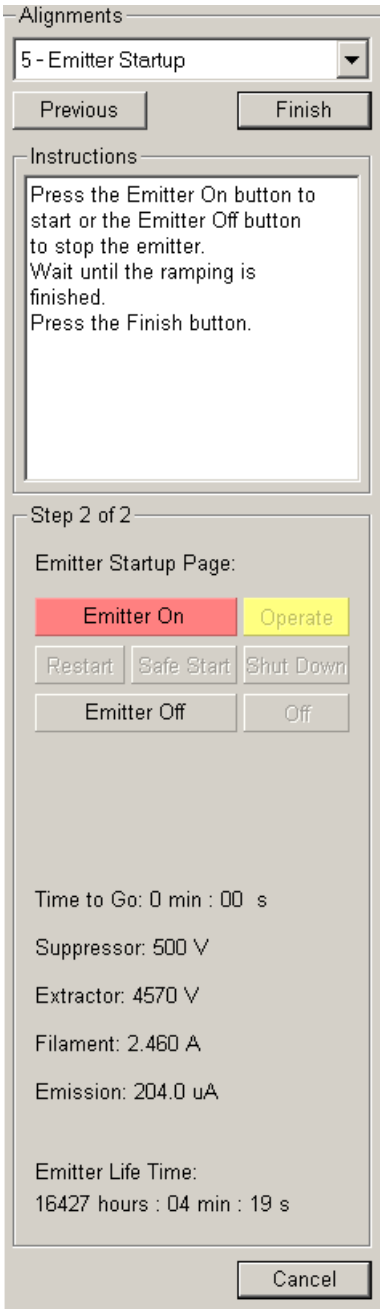


TABLE 9-35 5 STEP 2 OF 2

Order	Action
4	Click the **Emitter On** button. The startup will take a few minutes and will indicate **Safe Start** during run up.
5	When **Operate** is indicated the Emitter Startup is complete.
6	Click on the Finish button

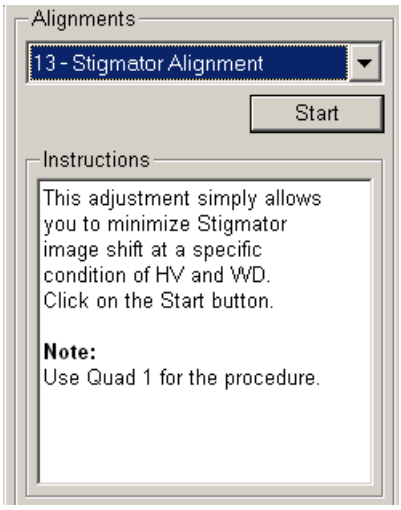
Field Name Functions

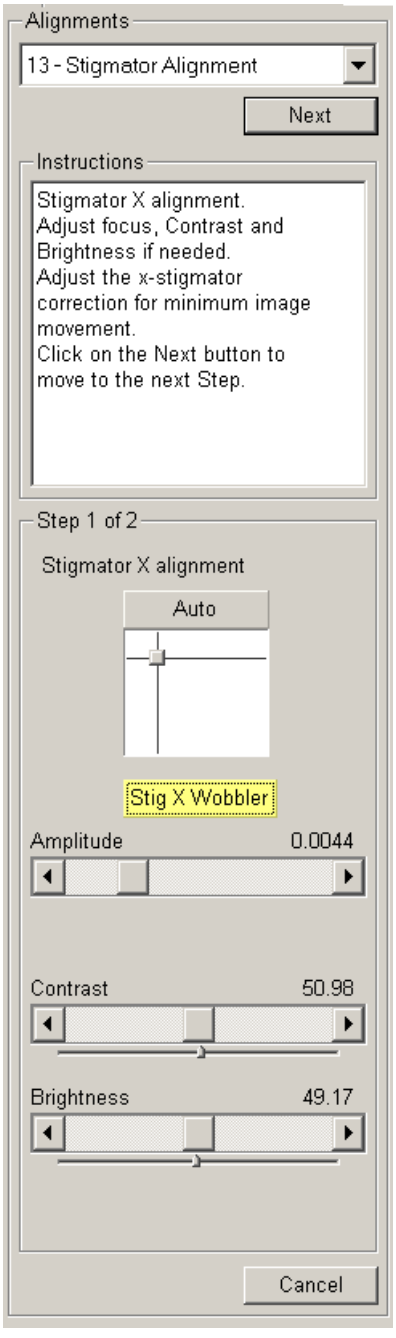
The pages for Emitter Startup are arranged with many functions and status readouts. Here are explanations of the important functions and status readouts:

TABLE 9-36 FIELD NAME AND STATUS

Field Name	Function
Emitter On / Off	starts / stops the emitter.
Restart	indicates that the emitter runs-up after a short emission interrupt.
Safe Start	indicates that the emitter runs-up with a slow run-up procedure.
Shut Down	indicates that the emitter is being switched off .
Operate	indicates that the emitter is in the operate state.
Off	indicates that the emitter is off.
Time to Go	indicates the time needed to complete the required action (Emitter On / Off).
Suppressor	shows the actual suppressor voltage.
Extractor	shows the actual extractor voltage.
Filament	shows the actual filament heating current.
Emission	shows the total emission current of the emitter.
Emitter Life Time	shows the actual emitter operating life time.

13 - Stigmator Alignment


Alignments
13 - Stigmator Alignment
Start
Instructions
This adjustment simply allows you to minimize Stigmator image shift at a specific condition of HV and WD.
Click on the Start button.
Note:
Use Quad 1 for the procedure.



User SEM Alignment

13 Stigmator Alignment corrects fine local changes to astigmatism shift in the Mode 1, 2 and 3. This alignment procedure can be used by every user at any time to compensate for image shift while adjusting the stigmator. It is a fast method compared to alignment 42 UHR Stigmator Align, which is only accessible to Supervisors.

Before you click on this function make sure you have an image with sufficient detail at at least 60,000x.

Follow the four-step procedure to minimize the image movement in both the X and Y direction using the X-Y controls available in the 2D control area.

Do Not change the aperture condition.

13 Stigmator Alignment

The **13 Stigmator Alignment** procedure starts here:

TABLE 9-37 13 NO STEP

Order	Action
1	Mode 1, 2 or 3 Specimen: Tin Balls. (any suitable sample) Steps: 2
1	Before you click on Start make sure you have an image with sufficient detail at 60,000x.
2	Press the Start button.

TABLE 9-38 13 STEP 1 OF 2

Order	Action
1	Optimize the image with Focus, Contrast and Brightness.
2	Click on the Stig X Wobbler and by using the 2D box labeled Stigmator X Alignment, eliminate the image shift. The Amplitude slider sets the wobbler modulating depth.
3	Click on the Next button.

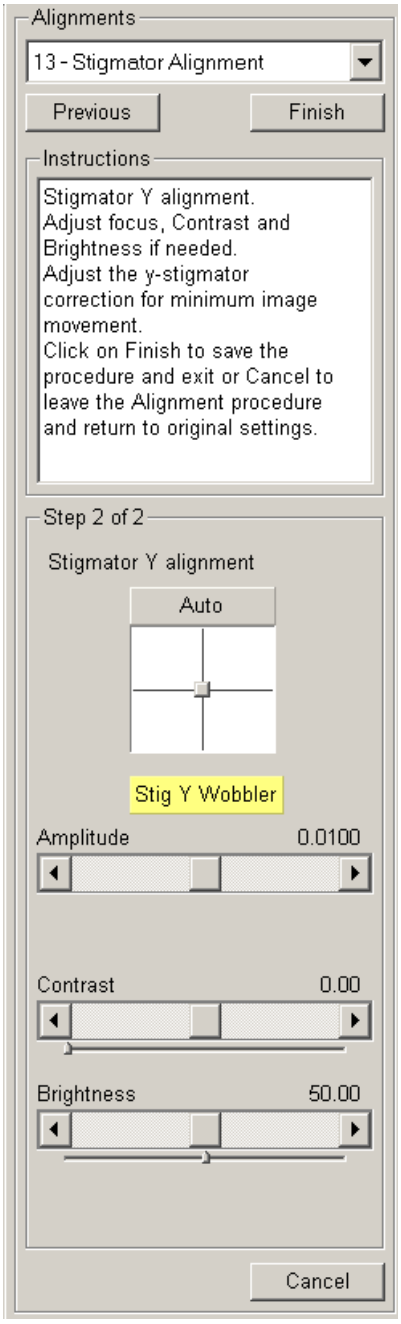


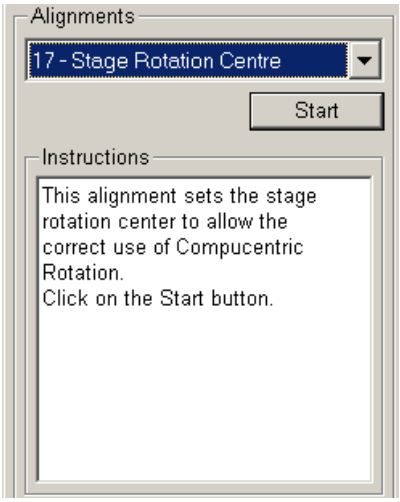
TABLE 9-39 13 STEP 2 OF 2

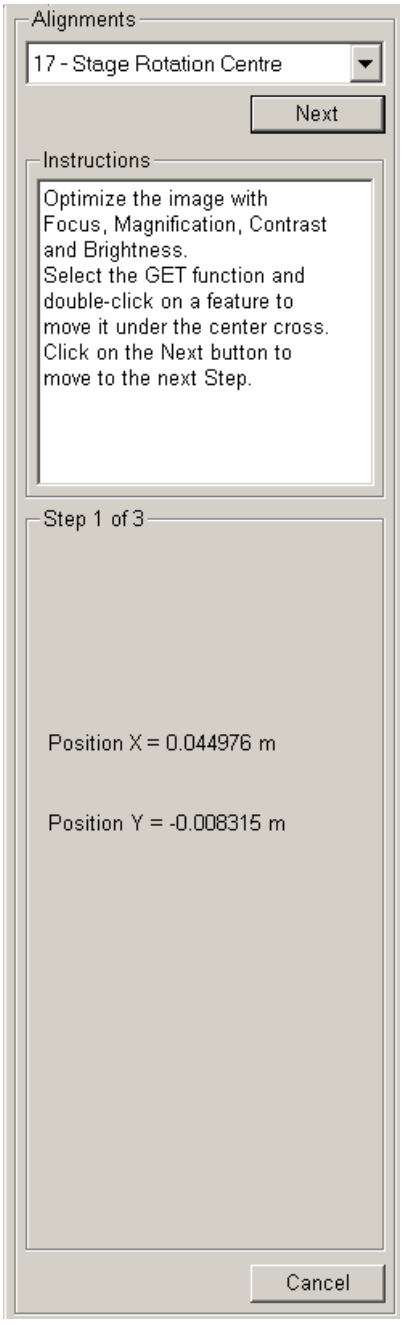
Order	Action
4	Click on the Stig Y Wobbler and by using the 2D box labeled Stigmator Y Alignment, eliminate the image shift. The Amplitude slider sets the wobbler modulating depth.
5	Click on the Finish button.

Auto Buttons

In some of the pages will be found Auto Buttons that achieve a similar result to the above described adjustments. It is possible to just click the Auto button. This function utilizes Image Recognition software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, lower magnification) or use the normal manual procedure.

17 - Stage Rotation Center


Alignments
17 - Stage Rotation Centre
Start
Instructions
This alignment sets the stage rotation center to allow the correct use of Compucentric Rotation.
Click on the Start button.


Alignments
17 - Stage Rotation Centre
Next
Instructions
Optimize the image with Focus, Magnification, Contrast and Brightness.
Select the GET function and double-click on a feature to move it under the center cross.
Click on the Next button to move to the next Step.
Step 1 of 3
Position X = 0.044976 m
Position Y = -0.008315 m
Cancel

User SEM Alignment

This alignment sets up the compensation factors for the stage X= 0 and Y = 0 positions, as well as the stage rotation center. The offset of X and Y are calculated in this procedure so that the Compucentric Rotation will be correct when computed at any later time. The procedure should be performed at zero tilt unless you are working at a specified tilt angle.

17 Stage Rotation Center procedure

The **17 Stage Rotation Center** procedure starts here:

TABLE 9-40 17 NO STEP

Order	Action
1	Mode 1 Specimen: Tin Balls. (any suitable sample) Steps: 3
2	Press the Start button.

TABLE 9-41 17 STEP 1 OF 3

Order	Action
3	Optimize the image with Focus, Contrast, Brightness and Magnification at 500x to 2000x.
4	Select the Get function and double-click on a feature close to the center of the stub mounted in the center of the stage (do not use IG stub holder or any other axis holder) at this magnification. Bring it under the screen Centre Cross by using the mechanical stage movement.
5	Click on the Next button.

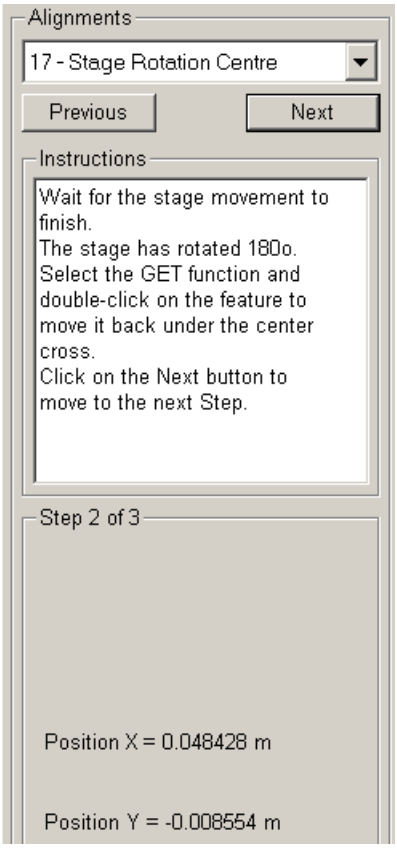

Alignments
17 - Stage Rotation Centre
Previous
Next
Instructions
Wait for the stage movement to finish.
The stage has rotated 180o.
Select the GET function and double-click on the feature to move it back under the center cross.
Click on the Next button to move to the next Step.
Step 2 of 3
Position X = 0.048428 m
Position Y = -0.008554 m

TABLE 9-42 17 STEP 2 OF 3

Order	Action
6	Wait for the Stage movement to finish.
7	Stage has rotated to 180°. Select the Get function and double click on the feature to move it back to the screen center.
8	Click on the Next button.

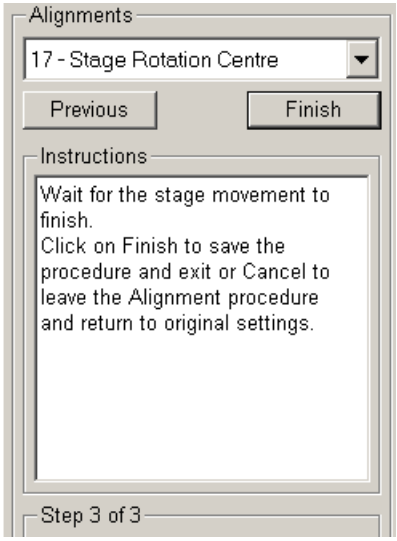
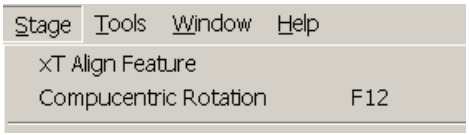

Alignments
17 - Stage Rotation Centre
Previous
Finish
Instructions
Wait for the stage movement to finish.
Click on Finish to save the procedure and exit or Cancel to leave the Alignment procedure and return to original settings.
Step 3 of 3

TABLE 9-43 17 STEP 3 OF 3

Order	Action
9	Wait for the Stage movement to finish.
10	Click on Finish to save the setting, or Cancel to return to the original setting.



To make use of this feature during normal operation go to the ‘Stage’ menu and select ‘Compucentric Rotation’, or press F12.

Ion-Column Alignment Overview

Supervisors only

This section describes procedures for Ion column electronic alignment for Supervisors only. These alignment functions are displayed in the Supervisor Alignment Page, Alignment - 210, 253 and 254. During electronic alignment, image motion is minimized and beam stigmation and focus are adjusted for each of the ion beam apertures. Additionally, image shift is corrected as necessary.

When all alignments are done properly, the image will stay in focus in the all ion beam currents if a sample is at the eucentric height, and the feature should stay exactly under the central cross after each beam current change. Before to start the alignment, the sample should be at Eucentric Height and the ion beam shift in the beam control page should set to zero.

TABLE 9-44 I-COLUMN ALIGNMENT ALLOCATION

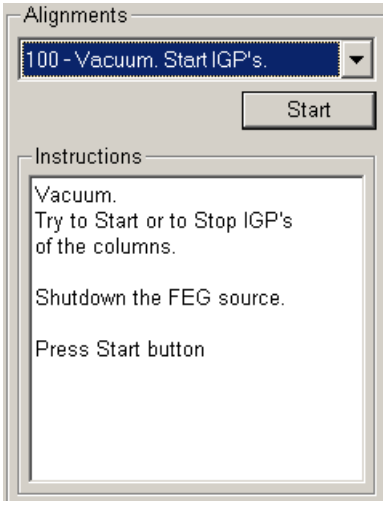
Procedures in order	Function
SUPERVISOR	
100 - Vacuum. Start IGP's	This procedure is to start the IGP's for the Electron column and the Ion column related to the system Startup after shutdown or due to a power failure.
210 - Source Tilt and Shift	Corrects source tilt and shift for the whole range of the accelerating voltages and spotsizes.
253 - Supervisor: Ion Beam	Eliminates image shift when focusing in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.
254 - Supervisor: GIS	Alignment Eliminates image shift during normal stigmator correction in Mode 2 (immersion mode) for the whole range of the accelerating voltages and working distances.

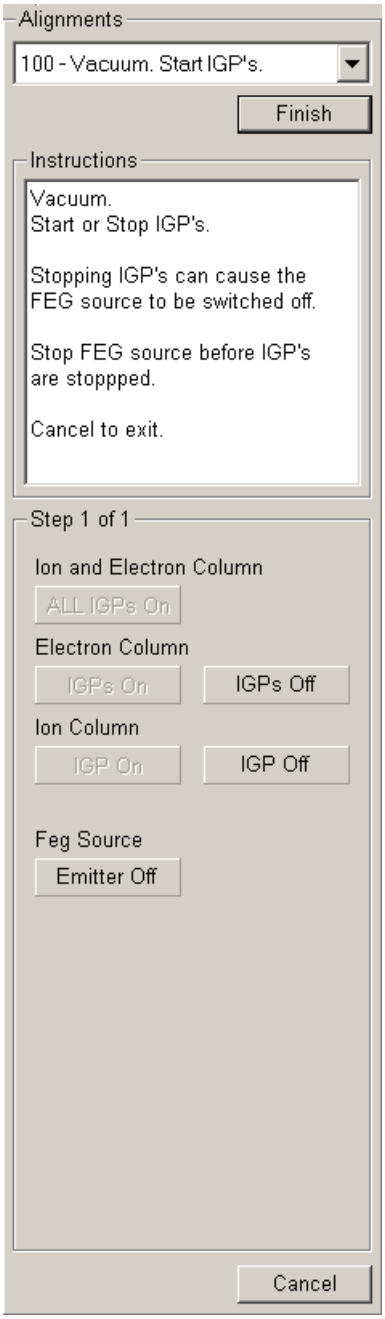
NOTE: Ion column electronically alignment is VERY important for the successful performance of automatic scripts, for instance AutoTEM and AutoFIB.

Ion column alignment procedures for the Sidewinder column consist of mechanical and electronic beam manipulations to correct asymmetries. These corrections are made to give the best beam performance over a full range of operations.

The purpose of alignment is to position the beam through the column for maximum beam transmission with minimum beam aberrations, minimizing image motion when you change or wobble lens voltage.

100 - Vacuum. Startup IGP's





Alignment Field Functions

This procedure is to start or stop the IGP's for the Electron column and the Ion column related to the system Startup after shutdown or due to a power failure.

TABLE 9-45 100 FIELD FUNCTIONS STEP 0 to 1

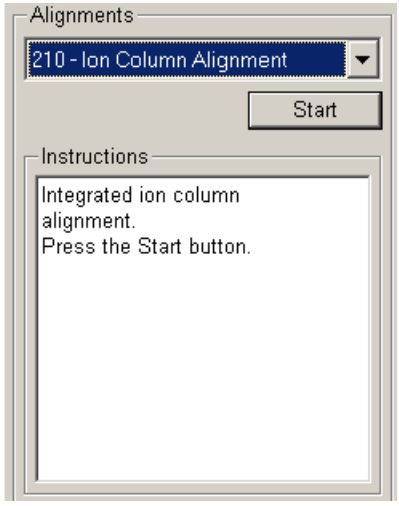
Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
Ion and Electron Column	**ALL IGP's On**: This button starts both Electron and Ion IGP's.
Electron Column	**IGP's On / Off**: These 2 buttons start or stop the Electron column IGP's.
Ion Column	**IGP On / Off**: These 2 buttons start or stop the Ion column IGP.
Feg Source	**Emitter Off**: Clicking on this button switches the Electron column source Off.
Cancel	Click on Cancel to leave the alignment and return to original settings.
Finish	Click on Finish to save the new setting.

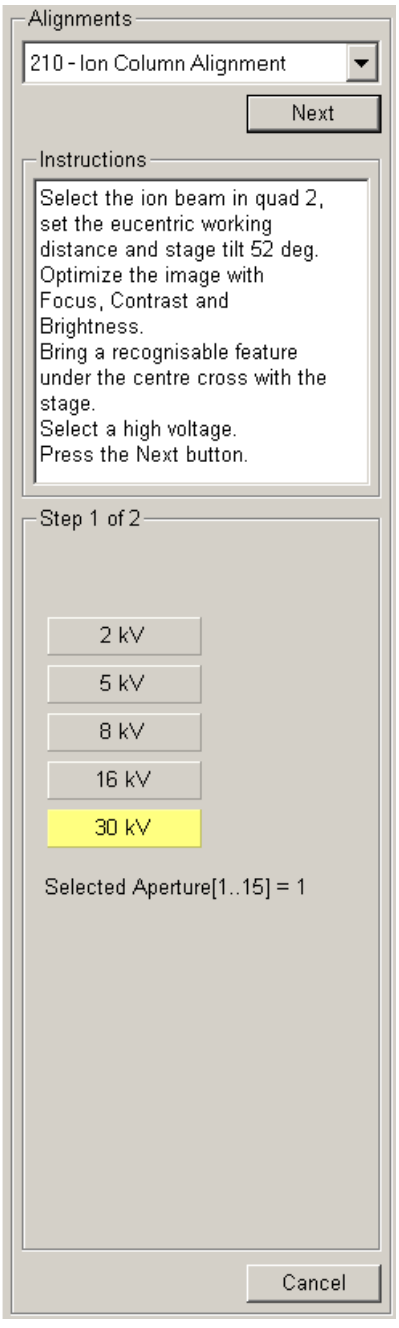
100 Vacuum. Start IGP's procedure

TABLE 9-46 100 NO STEP TO 1 OF 1

Order	Action
1	Press the Start button. Take note of the instructions.
2	ON - If the IGP' need to be started, either press the Electron Column IGP's On button first followed by the Ion Column IGP On button, or press the ALL IGP's ON button.
3	OFF - Press the Feg Source Emitter Off button to switch the Electron Source off before switching off any IGP's.
4	Click on Finish.

210 - Ion Column Alignment




Alignments
210 - Ion Column Alignment
Next
Instructions
Select the ion beam in quad 2, set the eucentric working distance and stage tilt 52 deg.
Optimize the image with Focus, Contrast and Brightness.
Bring a recognisable feature under the centre cross with the stage.
Select a high voltage.
Press the Next button.
Step 1 of 2
2 kV
5 kV
8 kV
16 kV
30 kV
Selected Aperture[1..15] = 1
Cancel

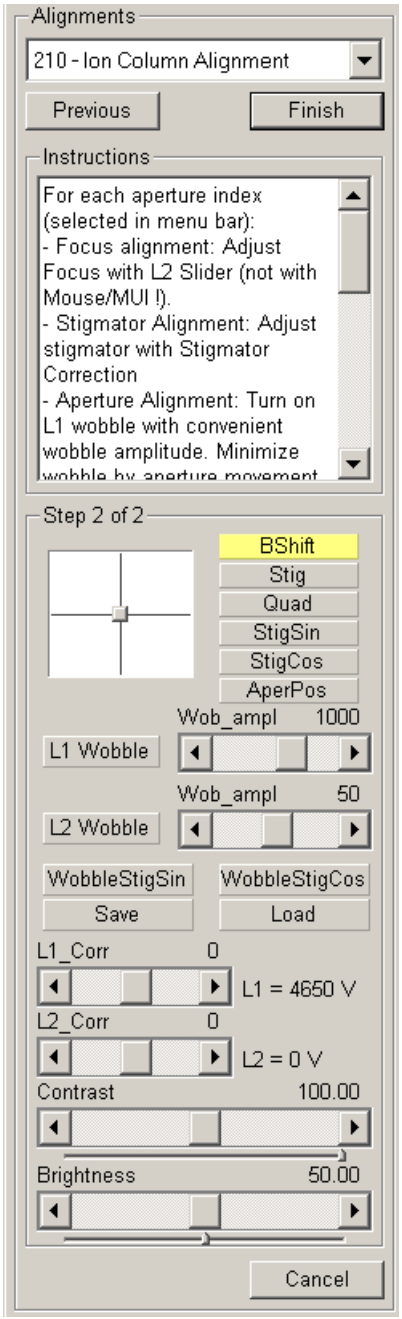
Alignment Field Functions

210 Field Functions Step 0 to 1

These alignment pages contain multiple functions and are a condensed version of previous separate alignment procedures. The Ion Column Alignment control areas shows the following functions.

TABLE 9-47 210 FIELD FUNCTIONS STEP 0 to 1

Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
High Voltage Buttons	Selected the High Voltage required from the buttons available.
Selected aperture	The selected aperture number is shown here.
Next	Click on Next to go to the following Step.
Cancel	Click on Cancel to leave the alignment and return to original settings.



210 Field Functions Step 2

The Ion Column Alignment control area shows the following functions.

TABLE 9-48 210 FIELD FUNCTIONS STEP 2

Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
Previous	Click on Previous to go to the previous Step.
Finish	Click on Finish to save the procedure and exit.
2D Control Buttons	BSHIFT (BUTTON) Click on BeamShift and use the 2D control to align the beam shift. STIG (BUTTON) Click on Stigmator and use the 2D control to align the stigmator. QUAD (BUTTON) Click on Quad and use the 2D control to align mid-column steering STIGSIN (BUTTON) Click on StigSin and use the 2D control to align the stigmator balance. STIGCOS (BUTTON) Click on StigCos and use the 2D control to align the stigmator balance. APERPOS (BUTTON) Click on Aperture Position and use the 2D control to align the aperture position.

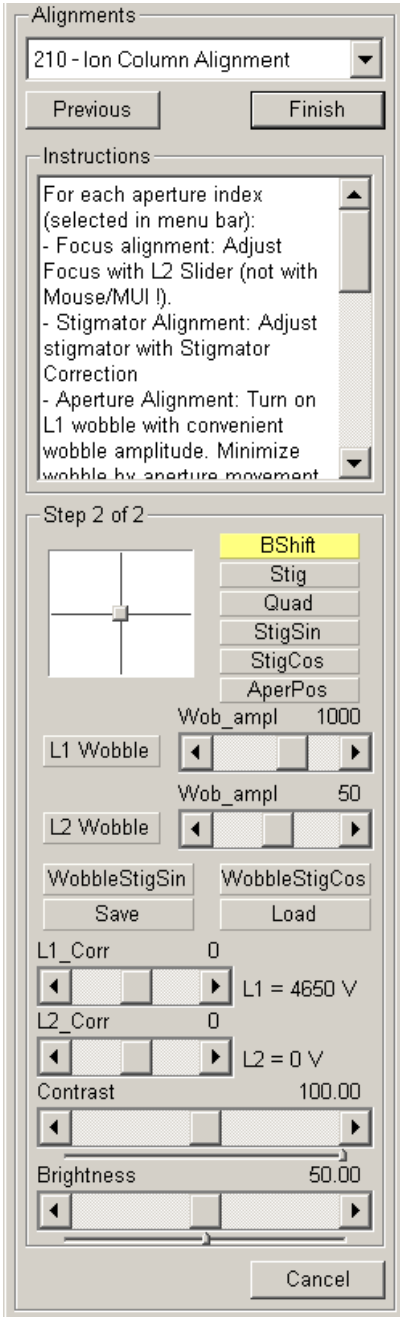
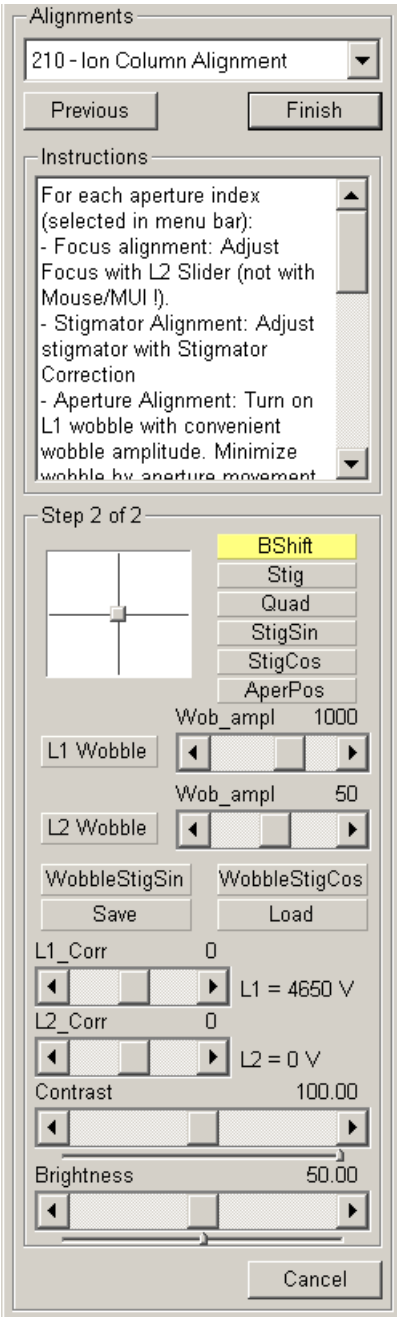


TABLE 9-48 210 FIELD FUNCTIONS STEP 2

Field Name	Function
2D XY control	Used in conjuction with any of the buttons above.
Wobbler Area	L1 / L2 WOBBLE (BUTTONS) Click on L1 / L2 Wobble to switch on. WOB_AMPL (SLIDERS) Use the Wobble Amplitude slider to create a convenient amplitude. WOBBLESTIGSIN (BUTTON) Button to switch on the stigmator Sin balance wobbler. SAVE (BUTTON) Click on the Save button to save Sin and Cos conditions. WOBBLESTIGCOS(BUTTON) Button to switch on the stigmator Cos balance wobbler. LOAD (BUTTON) Click on the Load button to Load Sin and Cos conditions. L1 CORR (SLIDER) Use the L1 correction slider to correct focus. L2 CORR (SLIDER) Use the L2 correction slider to correct focus. CONTRAST AND BRIGHTNESS (SLIDERS) Use the Contrast and Brightness sliders to correct the image.
Cancel	Click on Cancel to leave the alignment and return to original settings.



Alignment procedure

210 Step 0 to 2 Column Adjustment

The Ion column alignment procedure for the Magnum or SideWinder Column consists of electronic beam manipulations to correct asymmetries. These corrections are made to give the best beam performance over a full range of operations.

The purpose of alignment is to position the beam through the column for maximum beam transmission with minimum beam aberrations, minimizing image motion when you change or wobble lens voltage.

FIB alignments are started by calling the ion column adjustments page.

Beam Motion and Lens Wobbling

Wobbling Lens 1 / 2 voltage minimally changes focal length. If the beam passes off center through the lens, changing the focal length moves the image laterally. If the beam passes through the center of the lens, changing the focal length causes the image to go in and out of focus, but the image does not move.

Off-axis aberrations and the final spot size are minimized when the beam passes through the center of the lenses. The wobbling technique of varying the lens voltages provides a convenient method of viewing an off-axis beam as an apparent image motion.

Tips and tricks

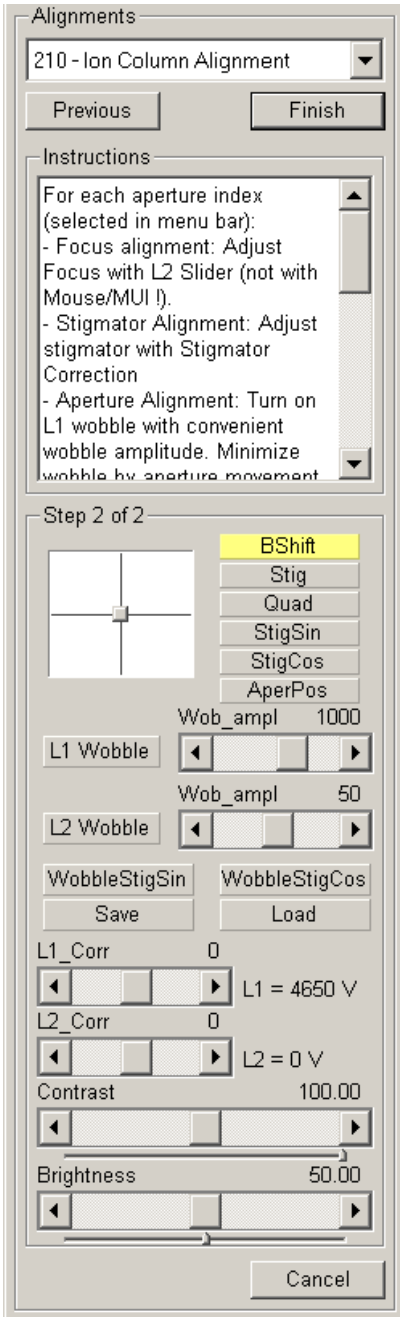
The amplitude for electronic wobble adjustment should be high enough to see reasonable motion/change of the image, but not so high that the image is out of focus.

Periodically click OFF and fine-tune the focus since the wobble changes the focus voltage. Don’t try to optimize focus or stigmation with the wobbler turned on.

For apertures less than 1000 pA, it is easiest to adjust wobble in the aperture by focusing on a feature of interest on the sample at a higher magnification.

The sensitivity of the two-dimensional X-Y control depends on the magnification level chosen. At higher levels, you may have to drag and release several times more for the same amount of adjustment than you would at lower magnification levels with a single drag.

Start at a lower magnification with stronger wobble strength. When you eliminate image motion, increase magnification and decrease wobble to minimize motion. Repeat until magnification is too high to make out features.



Motion, Stig and Focus Correction

The Procedure below is designed for both the Magnum and SideWinder columns, following the Instructions in the scrolling window will guide you through the correct alignment for your column type.

TABLE 9-49 210 STIG & FOCUS CORRECTION (part 1)

Order	Action
1	Load ‘test’ sample (FEI part # 19011) that came with the instrument. Drive to the ‘mapping wafer piece’. This is the piece with the ‘+ + +’ marks on it.
2	Log into supervisor mode
3	Get to eucentric height
4	Home Ion Beam AVA
5	Zero ion beam shift and zero scan rotation
6	Select the 100 pA Aperture and move to one of the features by double clicking. Set the magnification to 10kx.
7	Select Adjustment 210 ‘Ion column alignments’.
8	Press the Start button.
9	Read the Instructions in the scrolling window.

TABLE 9-50 210 STIG & FOCUS CORRECTION (part 2)

Order	Action - Magnum Column	Action - SideWinder Column
10	Select APERPOS. Turn on the L2 WOBBLE and adjust the Aperture position to get a reasonable image with little or no lateral movement while the image goes in and out of focus. Click and hold the left mouse button in the two-dimensional X-Y control. The cursor changes to the image of a hand and moves to the center of the screen. Move the Hand cursor side-to-side to minimize image motion. Release the left mouse button when you finished. Attempt to get the image to 'swell' only.	Select QUAD. Turn on the L2 WOBBLE and adjust the Quad Steering to get a reasonable image with a little or no lateral movement while the image goes in and out of focus. Click and hold the left mouse button in the two-dimensional X-Y control. The cursor changes to the image of a hand and moves to the center of the screen. Move the Hand cursor side-to-side to minimize image motion. Release the left mouse button when you finished. Attempt to get the image to, 'swell' only.
11	Select STIG SIN and turn on the WOBBLESTIGSIN. Reduce image wobble.	Select APERPOS. Turn on the L1 WOBBLE and reduce image wobble by adjusting the aperture position.
12	Select STIG COS and turn on the WOBBLESTIGCOS. Reduce image wobble.	Select STIG SIN and turn on the WOBBLESTIGSIN. Reduce image wobble.
13	Select STIG. Click and hold the left mouse button in the two-dimensional X-Y control and adjust the stigmation of the image for equal sharpness in all directions. Readjust focus with the L1 / L2_Corr adjuster or MUI knobs. Alternately adjust stigmation and focus to achieve the best image.	Select STIG COS and turn on the WOBBLESTIGCOS. Reduce image wobble.
14	Click SAVE when finished. Repeat step 4 - 8 for all apertures. (1pA, 10pA, 30pA, 50pA, 300pA…20.000pA).	Select STIG Click and hold the left mouse button in the two-dimensional X-Y control and adjust the stigmation of the image for equal sharpness in all directions. Readjust focus with the L1 / L2_Corr adjuster or MUI knobs. Alternately adjust stigmation and focus to achieve the best image.
15		Click SAVE when finished. Repeat step 4 - 8 for all apertures. (1pA, 10pA, 30pA, 50pA, 300pA…20.000pA).

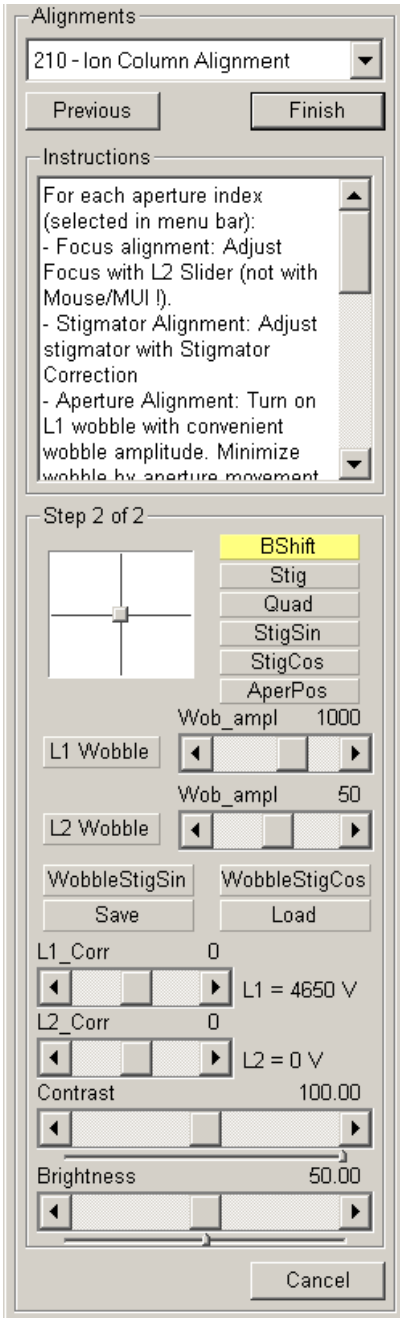


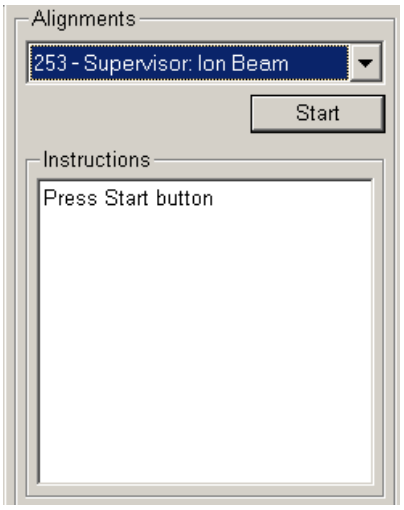
Image shift Correction

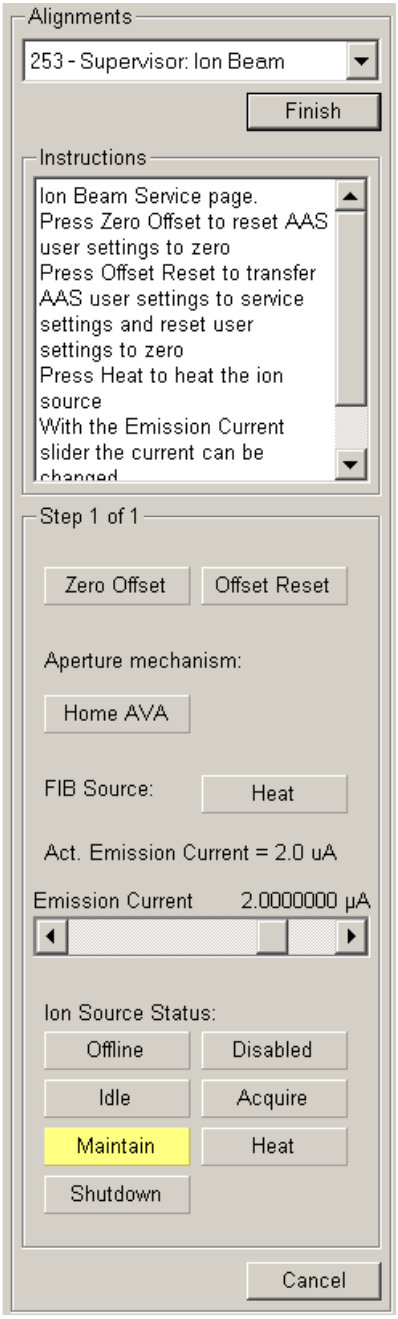
Correcting image shift is the final step in the column alignment process. This is not the beam shift used in imaging; it is a preprogrammed offset to correct for shift between apertures. A unique value is saved for each aperture.

TABLE 9-51 210 IMAGE SHIFT CORRECTION

Order	Action
1	Select 100pA aperture
2	Click BEAM SHIFT and ZERO. Find a distinctive feature of interest on the image and move to the center of the screen using the joystick or double-click with the mouse. Do not move the feature to the middle of the screen using a beam shift control.
3	Click SAVE and select the next aperture. (select either 50pA or 300pA)
4	Select BEAM SHIFT again. Position the cursor in the two-dimensional X-Y control, and click and hold the left mouse button. Drag the hand that appears to shift the feature within 0.5 µm of the same place onscreen as it was at the previous aperture. Release the mouse button.
5	Click SAVE when finished. Repeat beam shift correction (step 12 and 13) for all apertures.
6	Click FINISH When completely finished with the adjustment process.

253 - Supervisor: Ion Beam





Alignment Field Functions

This alignment is used to correct Offset in the positioning of the apertures from the alignment found in 210 Ion Column Alignment.

TABLE 9-52 253 FIELD FUNCTIONS STEP 0 to 1

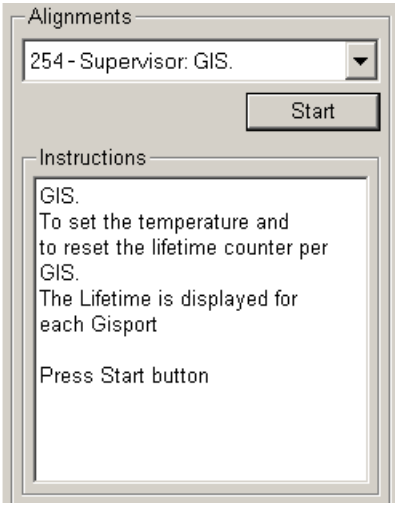
Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
Zero Offset	Click on this button to zero the offset created in the aperture positioning controlled in 210 Ion Column Alignment.
Offset Reset	Click on this button to reset the aperture positioning controlled in 210 Ion Column Alignment back to factory default. Useful if aperture position is totally lost.
Home AVA	Click on this button to move the Automatic Variable Aperture back to the the home position
Heat	Click on this button to Heat the ion source
New Source	Click on this button to reset ion source lifetime
Emission Current	Displays the Emission current set by the user
Start	Click on Start to go toStep 1.
Cancel	Click on Cancel to leave the alignment and return to original settings.
Finish	Click on Finish to save the new setting.

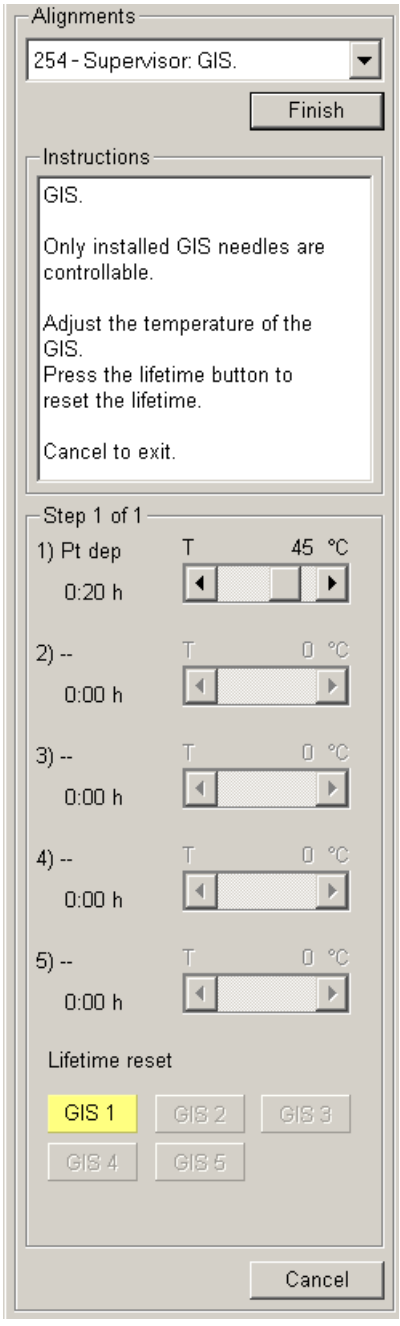
253 Supervisor: Ion Beam procedure

TABLE 9-53 253 STEP 0 to 1

Order	Action
1	Press the Start button.
2	Read the Instructions
3	Select the Offset button required.
4	Click on Finish to save the setting, or Cancel to return to the original setting.

254 - Supervisor: GIS





Alignment Field Functions

This page can be used by the supervisor to adjust Gas Injector temperatures.

TABLE 9-54 254 FIELD FUNCTIONS

Field Name	Function
Instructions	Follow the text to complete the step.
Step	Displays the present control area number and the total number of areas.
Numbers	Each number represents a GIS number. If a GIS is disabled the scrollbox will be greyed out.
Lifetim Reset	After GIS crucible replacement the lifetime can be reset by the supervisor.
Cancel	Click on Cancel to leave the alignment and return to original settings.
Finish	Click on Finish to save the new setting.

254 Supervisor: IGP procedure

TABLE 9-55 254 NO STEP TO 1 OF 1

Order	Action
1	Press the Start button.
2	Adjust the temperature of the GIS.
3	Click on the Lifetime Reset GIS# button if the lifetime needs reseting
4	Click on Finish to save the setting, or Cancel to exit